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Upper Air Research Laboratory

ROCKET INSTRUMENTATION FOR SOLAR ECLIPSE MEASUREMENTS– 12 NOVEMBER 1966

by

Karl G. Seljaas and David A. Burt

Contract No AF 19(628)-5044

Project No. 7663, 5710

Task No. 766307

Work Unit No. 76630701

Scientific Report No. 2

April 1967

Contract Monitor: James C. Ulwick

Upper Atmosphere Physics Laboratory

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Prepared for
Air Force Cambridge Research Laboratory
Office of Aerospace Research
United States Air Force
Bedford, Massachusetts 01730

University of Utah
Salt Lake City, Utah 84112

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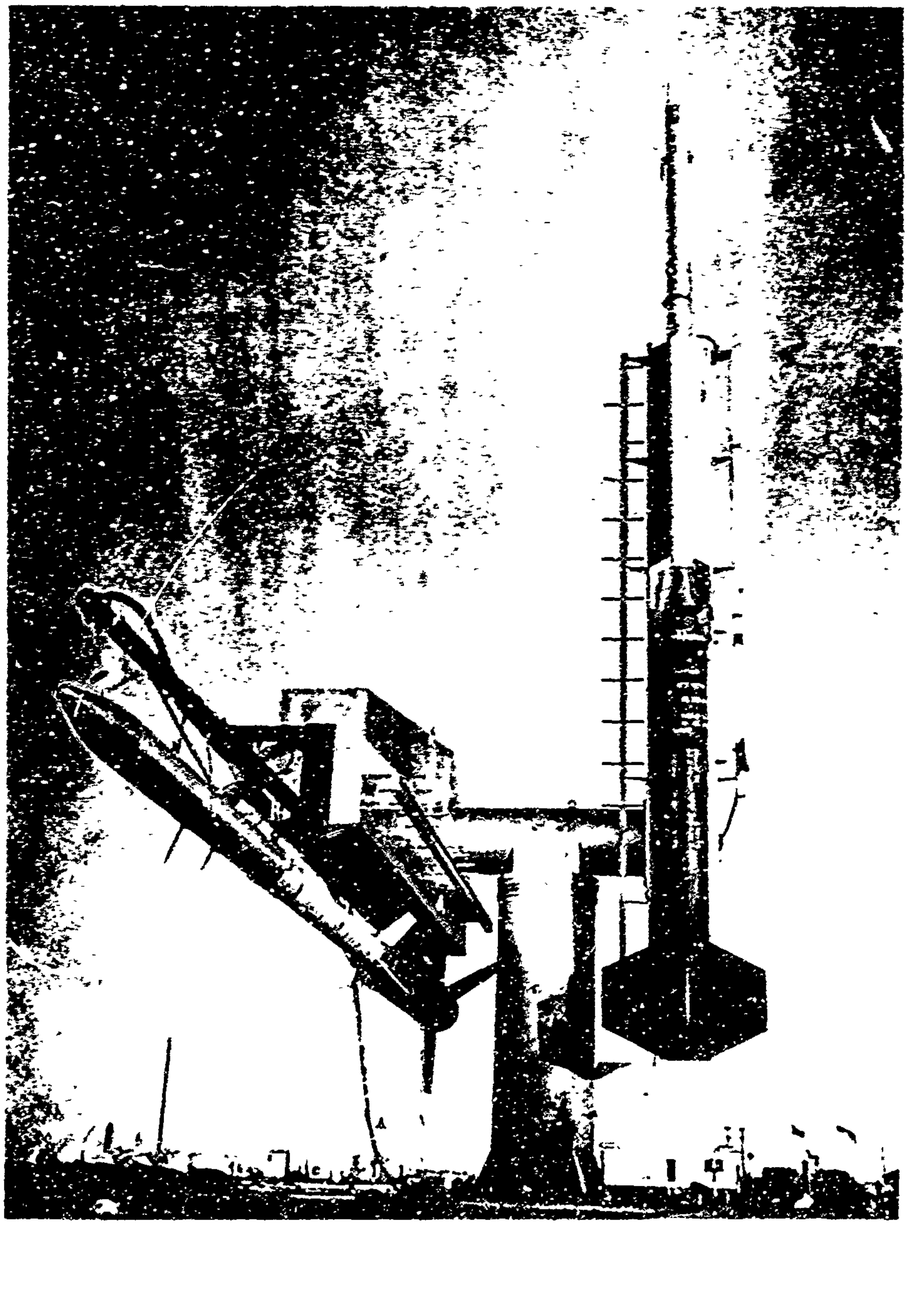
Submitted by Obed C. Haycock
Obed C. Haycock, Director



Eclipse rockets on launcher. Payload described in report is shown on the left. DASA 6.3 payload is on the right in launch position.

ABSTRACT

This report details instrumentation designed to measure the parameters in the D-region of the ionosphere during a total solar eclipse. Four Nike-Hydac rockets were fired from Cassino, Brazil, in connection with the eclipse of 12 November 1966; a test flight round was flown on 5 November, and the remaining three rockets were fired during various phases of the eclipse on 12 November.

Major emphasis is placed on the instruments developed by the University of Utah, although a brief description of the remaining instruments is included.

The rocket payloads were identical and were designed to measure the following parameters:

1. Positive ion composition
2. Positive ion density
3. Positive ion energy distribution
4. X-ray flux
5. Lyman-α radiation
6. Electron density
7. Electron temperature

LIST OF CONTRIBUTORS

SCIENTISTS AND ENGINEERS

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L. C. Howlett	Research Engineer
J. S. Hyatt	Research Engineer
K. G. Seljaas	Research Engineer

RELATED CONTRACTS AND PUBLICATIONS

AF 19(628)-4995

Despain, A.M., The Theory of Cylindrical Antenna Impedance as a Function of Plasma Frequency and Temperature, Scientific Report No. 1, Contract No. AF 19(628)-4995, AFCRL-65-480, March 1965.

Despain, A.M., Antenna Impedance in the Ionosphere, Scientific Report No. 3, Contract No. AF 19(628)-4995, AFCRL-66-412, UU-66-7, May 1966.

Linford, R.K., and K.D. Baker, Impedance Measurements of Unbalanced Rocket Antennas Near the Earth's Surface, Contract No. AF 19 (628)-5044, Scientific Report No. 1, AFCRL-66-658, UU-66-10, August 1966.

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I. INTRODUCTION

This report describes instrumentation developed for the study of electron and ion densities, ionizing radiation fluxes, and the resulting reaction rates in the D-region of the ionosphere during the total solar eclipse of 12 November 1966. The instruments were carried aloft by four Nike-Hydac rockets launched from Cassino, Brazil. The four payloads were essentially identical. A payload certification round was fired on 5 November 1966, and the three remaining payloads were launched during different phases of the eclipse on 12 November 1966, as shown in Table 1. The map in Figure 1 depicts the position of the launch site and the path of the eclipse as well as giving launch data for the rockets.

TABLE 1. Launch Times for Eclipse Rockets

Rocket Designation	Launch Date	Launch Time (Local Time)*	Time from totality, min & sec	Approximate apogee, km
Certification Round	5 Nov 1966	1155:21	-	95.7
D-4	12 Nov 1966	1155:19	-16:00	115.0
D-11	12 Nov 1966	1208:37	-01:23	115.0
D-13	12 Nov 1966	1222:30	+12:30	115.0

*Local Time = Universal Time - 2 hours

2

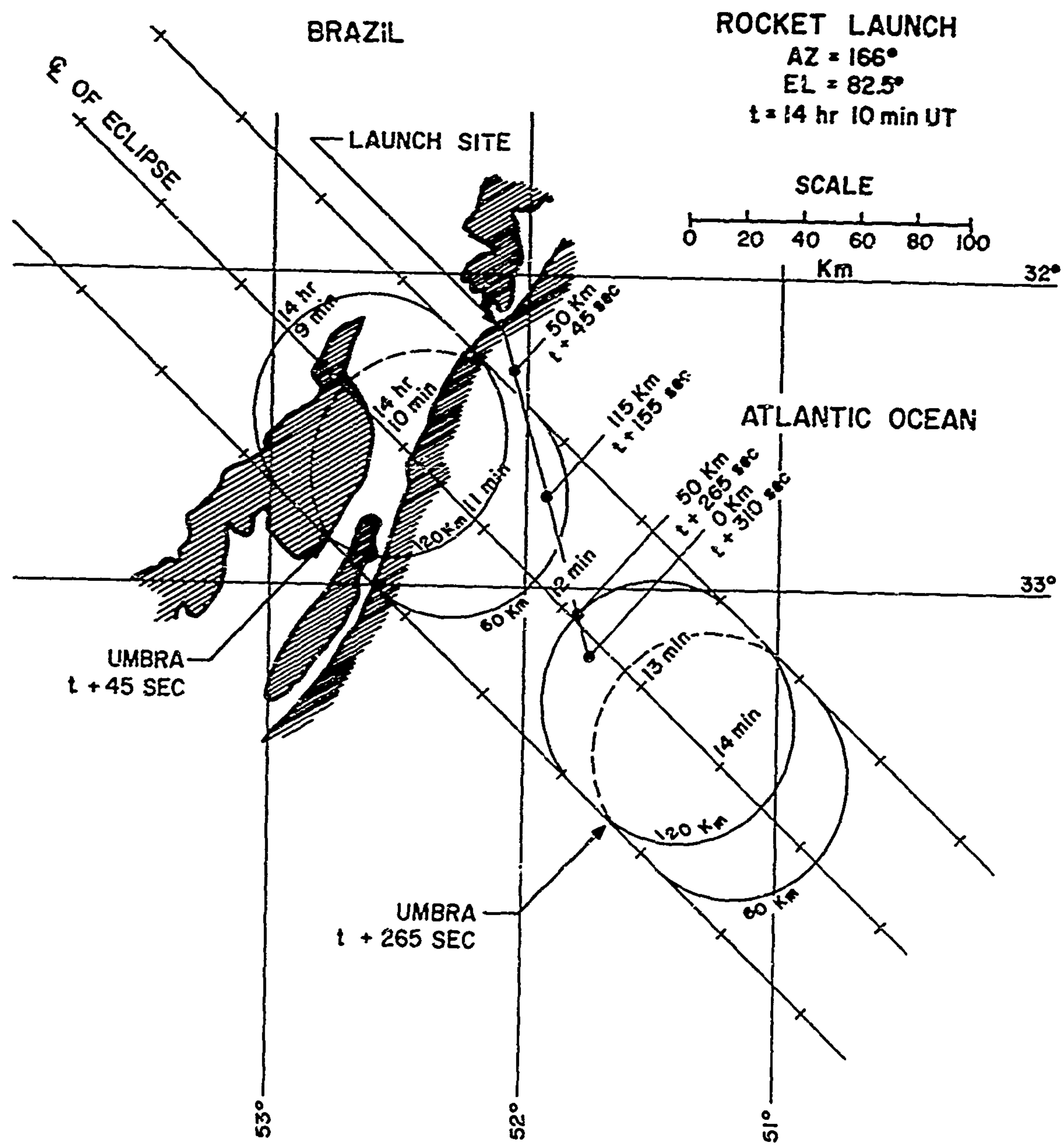


Fig. 1. Eclipse path and proposed launch angle.

A brief description of the instruments flown in the eclipse rockets (see Table 2) are given; however, the major emphasis will be placed on the two electron density probes developed by the University of Utah.

TABLE 2. Instruments in Eclipse Rocket Payloads

Instrument	Responsible Agency	Measurements
Mass spectrometer	Air Force Cambridge Research Laboratories (CRUZ)	Positive ion composition
Ion trap	Air Force Cambridge Research Laboratories (CRUB)	Positive ion density
Retarding potential analyzer	Adcole Corporation	Positive ion density & energy distribution; electron density & energy distribution
X-ray counter	GCA Corporation	X-ray flux in 1-10 A and 44-60 A range
Lyman-α chamber	GCA Corporation	Lyman-α radiation (1216 A)
Langmuir probe	University of Utah	Electron density and temperature
Standing wave impedance probe	University of Utah	Electron density

I. INSTRUMENTATION

Mass Spectrometer

The mass spectrometer, developed at Air Force Cambridge Research Laboratories, samples positive ions at altitudes greater than 50 km. Positive ions which enter a small sampling orifice at the front of the instrument are accelerated and sorted such that only ions with specific mass-to-charge ratios are sampled at given values of the accelerating voltages. The focused ion current is amplified and measured with a logarithmic electrometer. The reader is referred to the literature for a detailed description of the mass spectrometer [*Narcisi and Bailey*, 1965].

Ion Trap

The ion trap was designed and constructed at Air Force Cambridge Research Laboratories. The experiment consists of applying suitable bias voltages between elements of a spherical, electrostatic analyzer and monitoring the resulting probe currents. The experimental data are obtained by operating in the following modes:

Mode 1: This is the primary mode of operation. Fluctuation of charged-particle density is obtained by applying a fixed, negative saturation voltage between the grid and the collector of the spherical probe.

Mode 2: In this mode of operation, the system operates as a Langmuir probe. A linear sweep voltage is applied to the outer grid while the collector is maintained at saturation. Vehicle potential, positive ion

energies and temperatures can be deduced from this mode of operation.

Mode 3: This mode of operation furnishes information on differential energy distribution and serves as an experimental check on the required saturation voltage for Mode 1 operation. The data are obtained by keeping the outer grid at vehicle potential while the collector is stepped from the saturation voltage to zero.

Detailed description of this experiment is given elsewhere [*Sagalyn and Smiddy*, 1964] and will not be discussed further here.

Retarding Potential Analyzer

The retarding potential analyzer measures positive ion density and energy distribution. A block diagram of the system is shown in Figure 2.

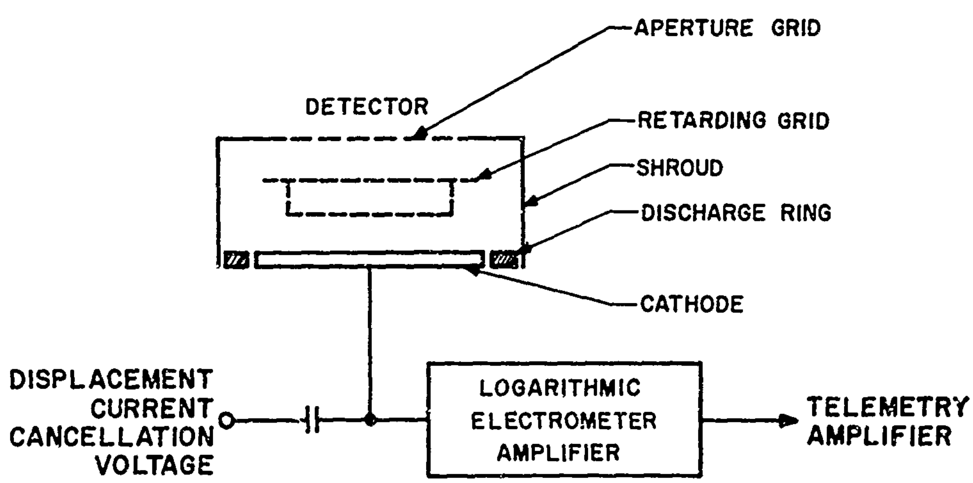


Fig. 2. Retarding potential analyzer block diagram.

The flow of particles into the detector is controlled by the aperture grid which is connected to the rocket body for positive ion measurements. Since the rocket body is one to two volts negative with respect to space potential, the aperture grid is also negative by this amount. The energy analysis is made by varying the potential on the retarding grid from +6 to -4 volts and measuring resulting cathode current. A more complete description of this experiment is given by *Hinteregger* [1960].

Solar Radiation Detectors (X-ray and Lyman-α)

The solar, ionizing radiation was measured by X-ray and Lyman-α detectors. X rays in the 1-10 A range and the 44-60 A range were measured by Geiger counters, while an ion chamber, having a range from 1050 to 1240 A was designed to detect the Lyman-α radiation (1216 A). The detectors were oriented in a direction such that the attitude control system of the rocket would provide a field of view in the solar direction. Detailed description of similar instruments is given by *Smith et al.* [1964].

Langmuir Probe

The Langmuir probe is a useful instrument for determining electron temperature and density. Basically, this probe operates by applying a programmed voltage to an electrode immersed in the plasma and measuring the electrode current. From the resulting current-voltage curves, the electron density and temperature can be obtained. This basic technique has been described in detail and is referred to in the writings of *Langmuir and Mott-Smith* [1924] *and Smith* [1964].

INSTRUMENTATION

The Langmuir probes as used for the solar eclipse program by the University of Utah are shown in the block diagram of Figure 3.

The four flight probes were identical except for slight adjustments in signal sensitivity.

It was deemed desirable to measure temperatures down to 100° K and densities down to 100 electrons/cm^3 with an upper limit of 2000° K and 10^6 electrons/cm^3. The threshold measurement is determined by the amplifier sensitivity and the total area of the sensing electrode. By using the threshold values stated above, a calculation of random current density was used as a guide in determining the probe area.

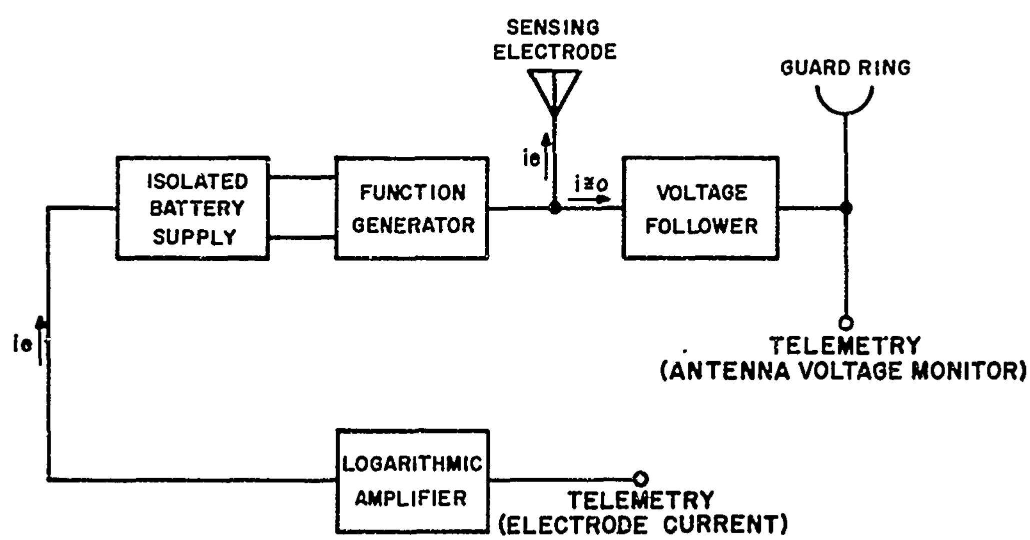


Fig. 3. Langmuir probe block diagram.

Sensing Electrode

A drawing of the sensing electrode is shown in Figure 4. A voltage identical to the voltage on the sensing electrode is applied to the guard electrode to reduce the error due to edge effects on the sensing probe. The guard electrode is isolated electrically from the sensing element, and only the current to the sensing electrode is measured. Two identical sensing elements were flown so that the total sampling probe area was 21 cm^2.

Log Amplifier

The variation of the electrode current over the anticipated range of densities and temperatures requires a dynamic range of nearly five decades. This dynamic range was obtained by use of a high gain amplifier and logarithmic compression as shown in the schematic of Figure 5. The HPA 0102 diodes used in the feedback loop were selected because of their logarithmic relationship between voltage and current over the nearly five decades. It was necessary to use two diodes in the feedback loop since both positive and negative currents were monitored. The gain of the amplifier was held constant by maintaining the feedback diodes at a constant temperature in an oven.

Transistor Q_1 is a source follower (FET) which provides high input impedance. The gate current should be at least an order of magnitude smaller than the minimum electrode current. The 709C operational amplifier (A_1) provides the amplification, and the 1000-ohm potentiometer (R_1) in the output circuit of the operational amplifier provides a means of adjusting the slope of the transfer characteristic curve.

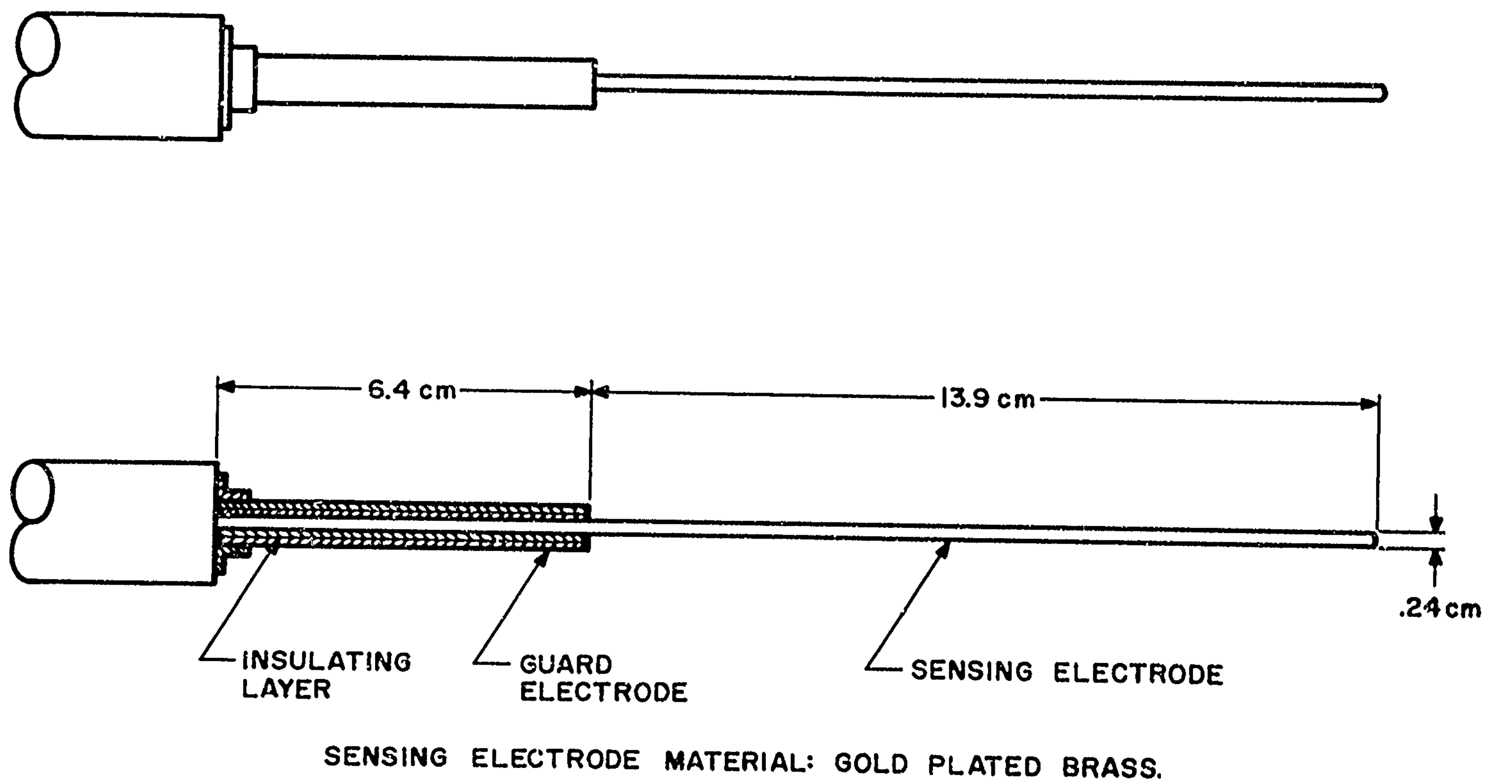


Fig. 4. Langmuir probe electrode configuration.

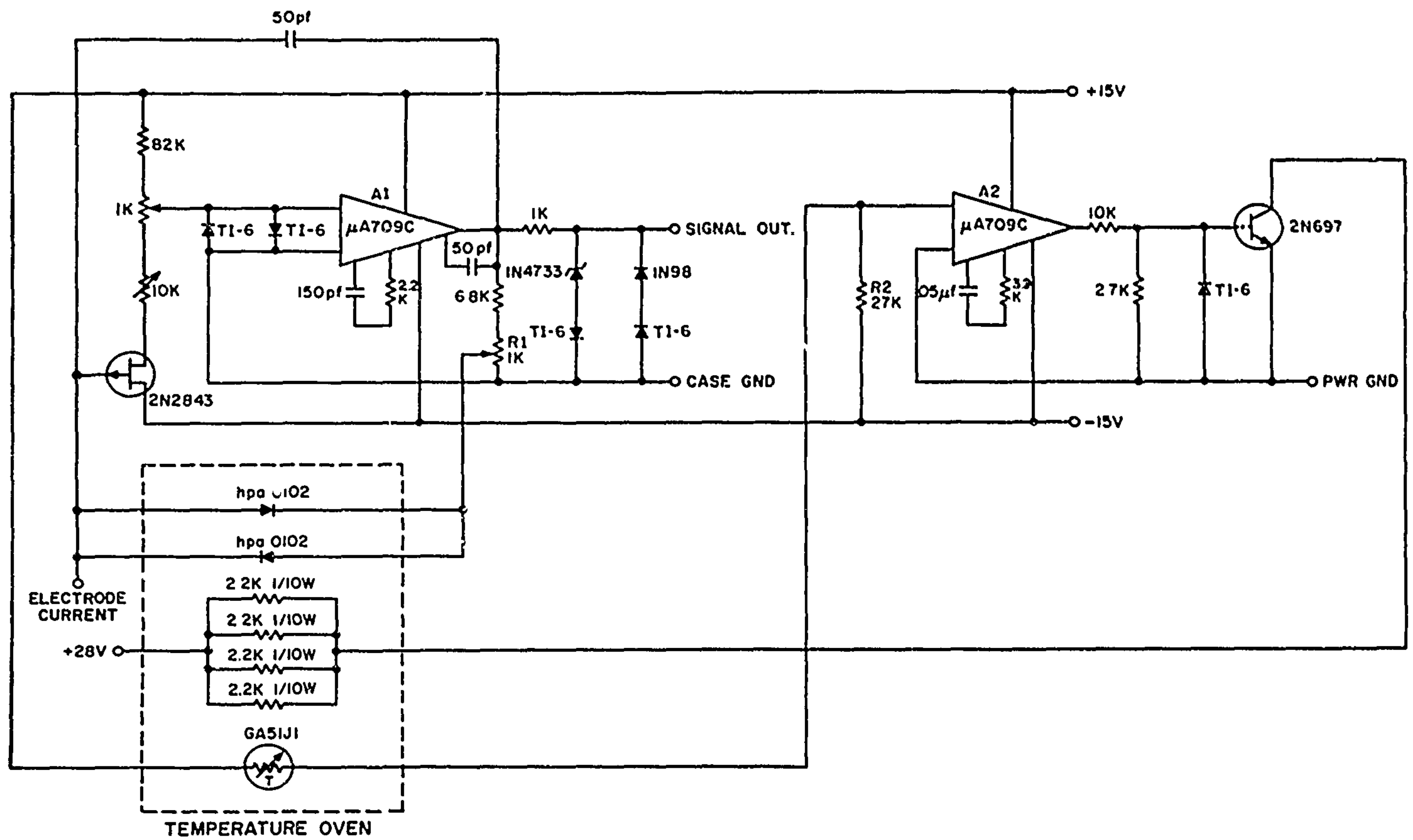


Fig. 5. Langmuir probe logarithmic amplifier.

The temperature-stable oven is controlled by a GA51J1 thermistor imbedded in heat-conductive potting along with the log diodes and the four 2.2-K resistors (1/10 W) that serve as the heating element. Due to the high amplification of the 709C operational amplifier (A_2), minimal change in the oven temperature (and hence the thermistor resistance) is required to switch the 2N697 transistor controlling the heater current. The temperature of the oven was set at 40° C: however, by simply changing the value of the R_2, the oven temperature could be adjusted to any desired value. The oven is capable of controlling the temperature to within about 2° C of the nominal value.

The minimum detectable signal current is limited by the magnitude of any shunt currents at the input of the amplifier and the minimum leakage current in log diodes in the feedback. The total leakage current limited the amplifier to a minimum detectable signal current of 5×10^{-9} amps.

Function Generator

The function generator for creating the electrode voltage is shown in the schematic of Figure 6. Separate batteries are necessary in order to electrically isolate the function generator from the remainder of the instrument, thereby making possible direct measurement of electrode current. The switching relays are closed only when dc power from the main power source is applied to the instrument. In this way, the function generator batteries provide about six hours of operating time with provision being made to charge them through diodes CR1 and CR2.

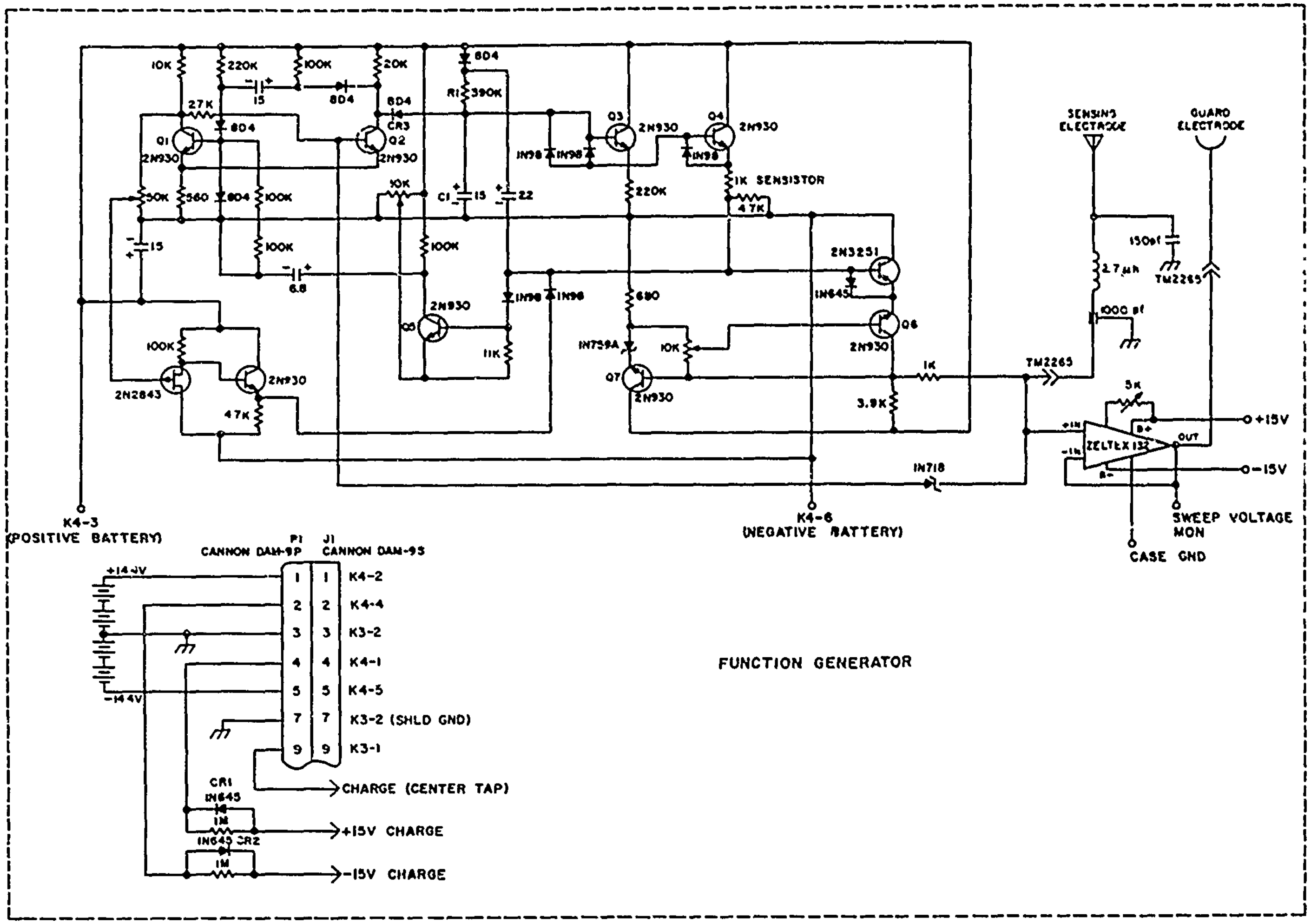


Fig. 6. Langmuir probe function generator.

The function generator produces the desired electrode voltage as shown in Figure 7. Transistors Q_1 and Q_2 form a monostable multivibrator. Diode CR3 is back-biased when transistor Q_2 is cut off thus providing charging current to capacitor C_1 through R_1. Transistors Q_3 and Q_4 form a bootstrap circuit to linearly charge C_1. When the sweep voltage reaches a predetermined magnitude (5 volts), voltage pickoff stage Q_5 sends a trigger signal to the multivibrator. At this time the output is a dc voltage, determined by Q_5 and Q_6, which continues until the multivibrator switches back to its initial state and the sweep cycle is repeated.

The output voltage from the generator is applied to the sensing electrode and the current is monitored by connecting the log amplifier to the center tap of the batteries. This is the only valid current path to ground so the current should be equal to the electrode current.

A high input impedance voltage follower is also connected to the output of the generator. This circuit, consisting of a Zeltex model 132 operational amplifier, forces the guard electrode potential to follow that of the sensing electrode; yet no measurable current flows to the voltage follower since the input impedance is over 10^{12} ohms. The output of the voltage follower is also monitored on telemetry so that the electrode voltage is known at all times.

<u>Converter</u>

The ±15 volt operating voltages were obtained from the dc-dc converter shown in Figure 8.

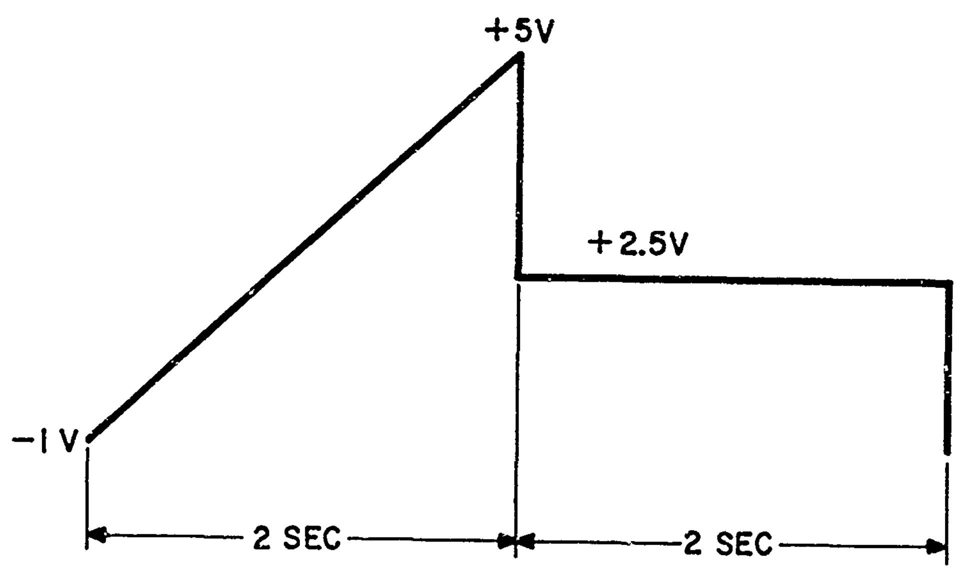


Fig. 7. Voltage applied to Langmuir probe electrode.

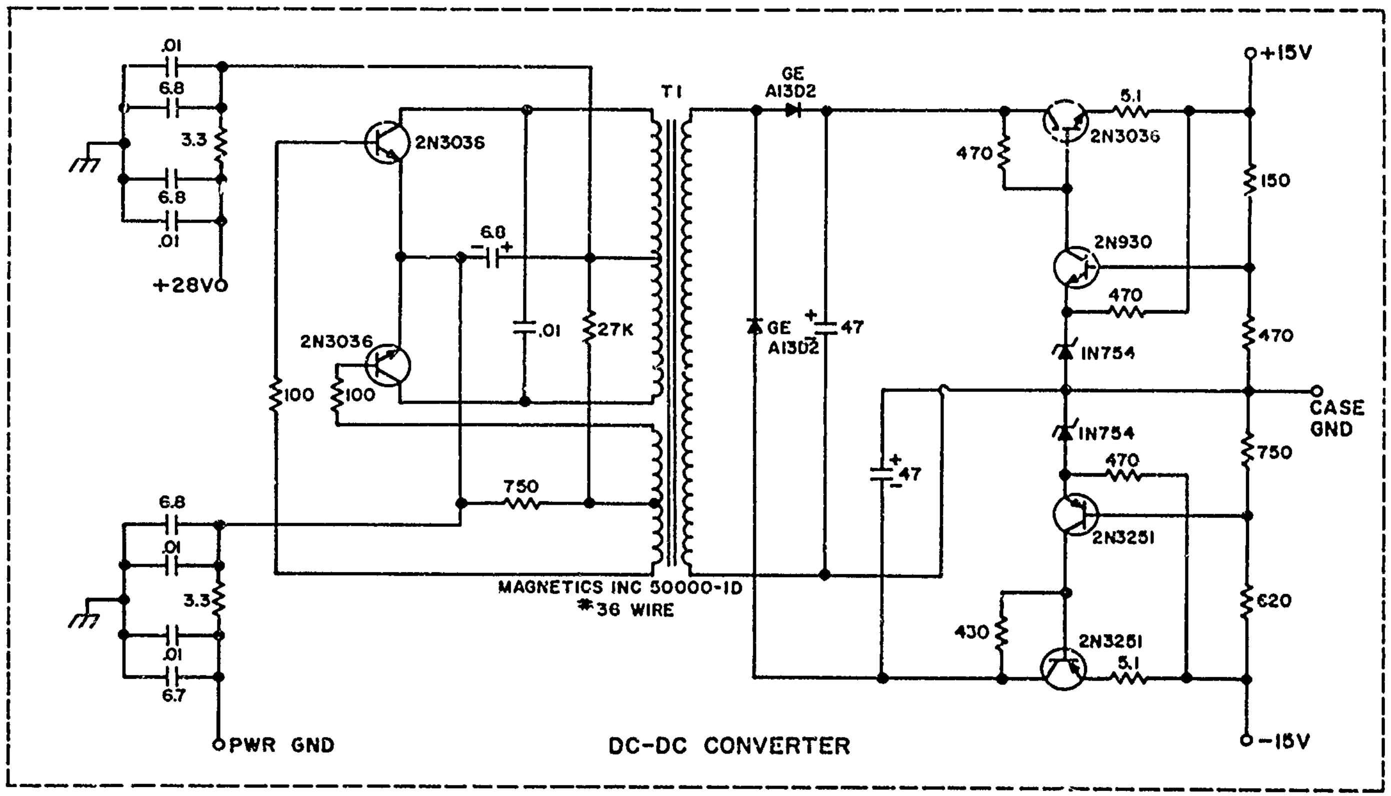


Fig. 8. Langmuir probe dc-dc converter.

Calibration Circuit

The calibration circuitry shown in Figure 9 consists of a free-running multivibrator Q_1 and Q_2 with a ten-second pulse interval driving a second multivibrator Q_3 and Q_4 which energizes relays K1 and K2. An open circuit is utilized for half of the calibrate time, a current of 1 μa is then applied to the amplifier input for the last half of the calibrate period. At the end of the calibrate period, the relays are reset so that the electrode current is again monitored.

Preflight Calibration

Prior to flight, the system is calibrated by applying known currents to the amplifier and reading the output voltage. Calibration curves for the four rocket flights are shown in Figures 10 through 13. Since the system is slightly temperature-sensitive, the instrument included temperature monitors. The temperature monitor calibration voltages are shown in Table 3.

TABLE 3. Langmuir Probe Temperature Monitor Calibration

Temperature (°C)	Monitor Voltage (Volts)			
	Unit 3 (Cert Rnd)	Unit 7 (D-4)	Unit 5 (D-11)	Unit 6 (D-13)
10	1.65	1.40	1.70	1.80
20	2.10	2.00	1.80	2.30
30	2.75	2.50	3.20	2.80
40	3.80	3.50	3.80	3.70
50	4.90	4.20	4.30	4.90

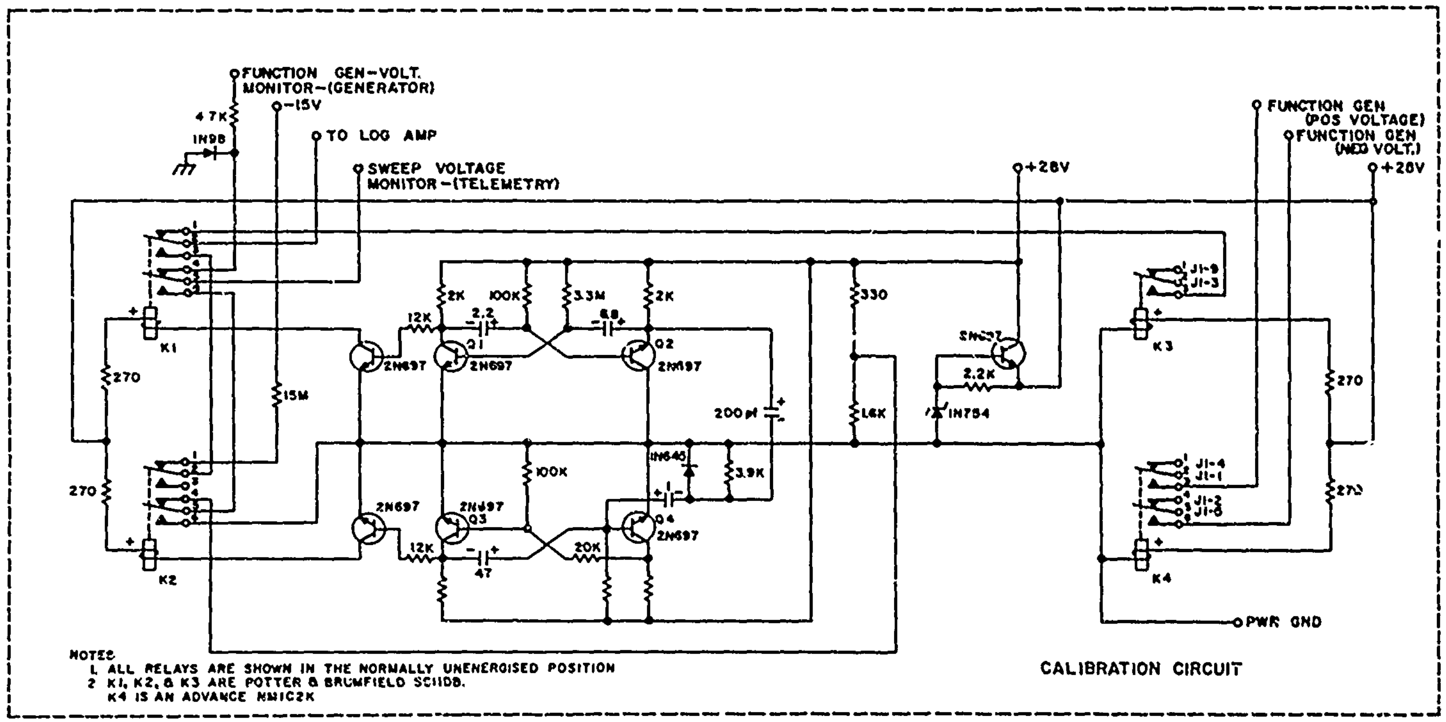


Fig. 9. Langmuir probe calibration circuit.

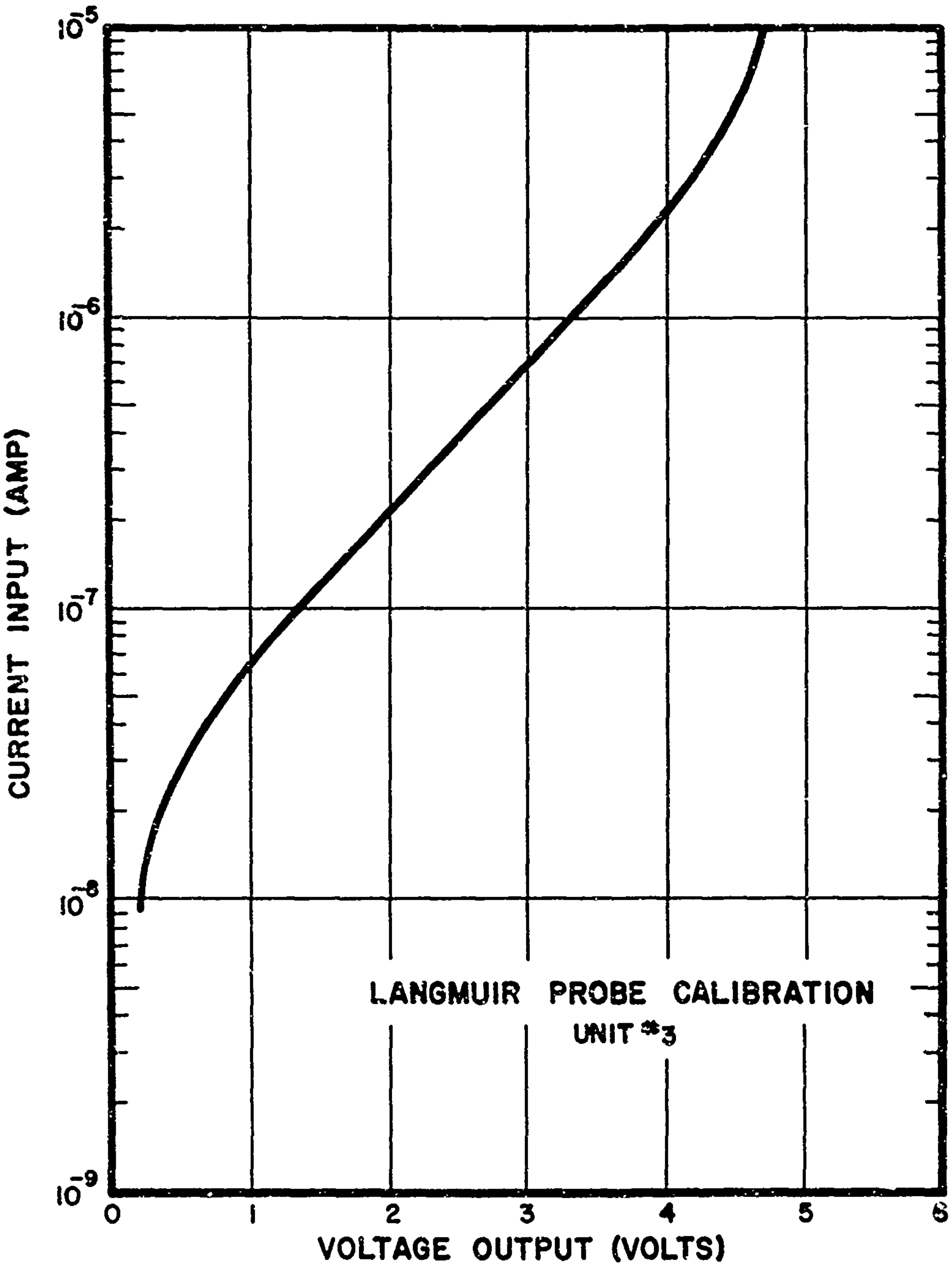


Fig. 10. Langmuir probe amplifier calibration - certification round.

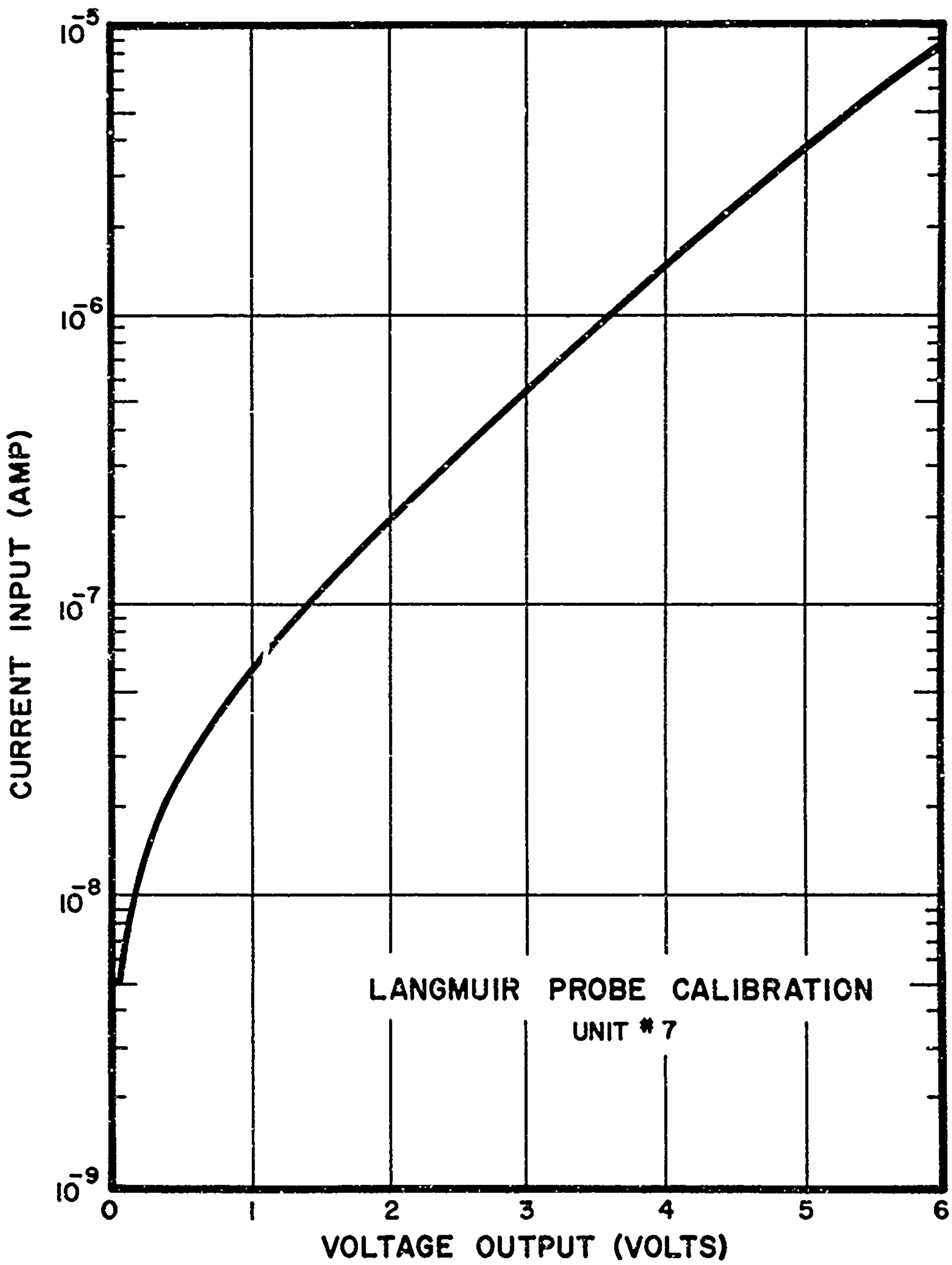


Fig. 11. Langmuir probe amplifier calibration - D-4.

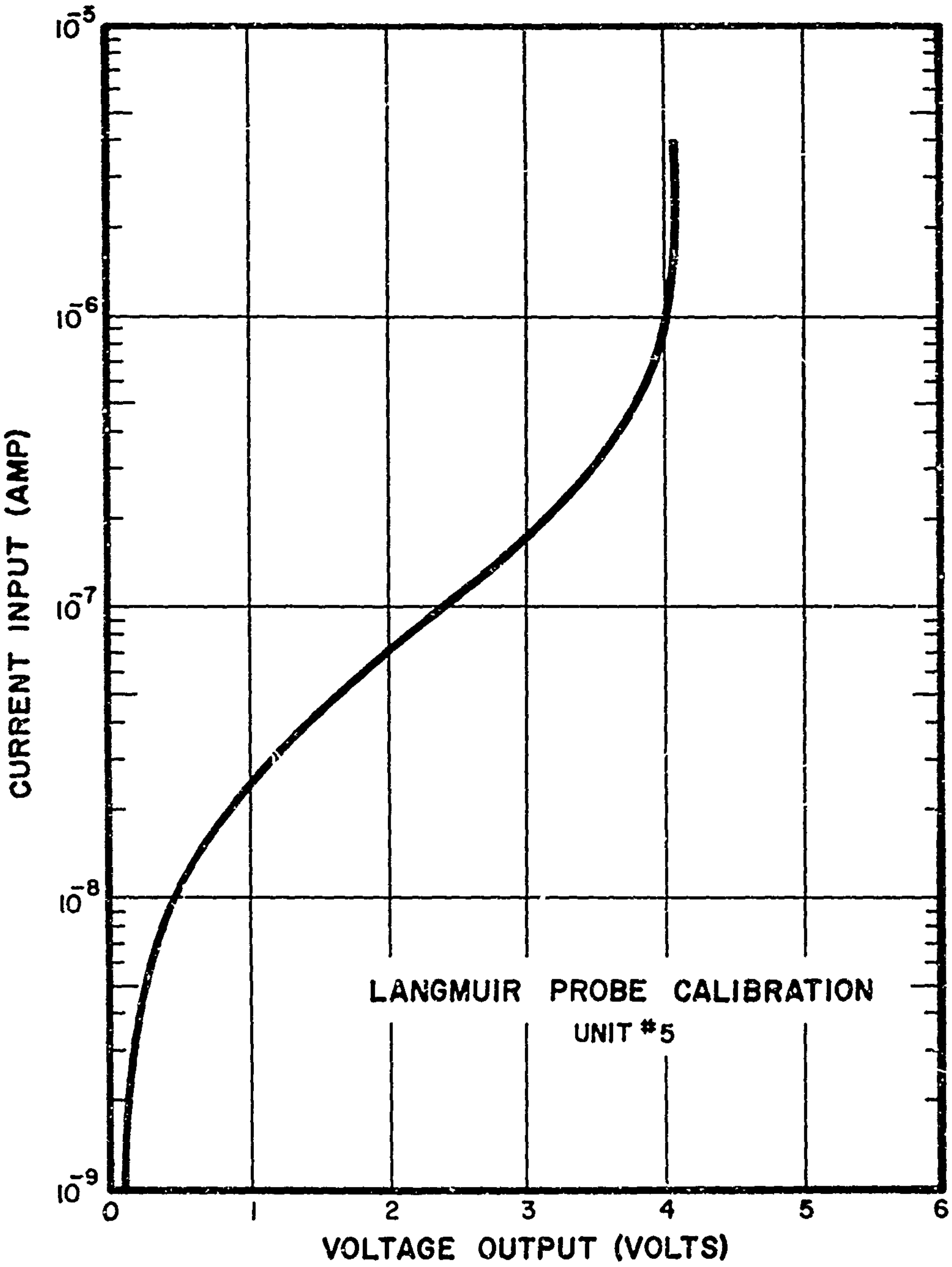


Fig. 12. Langmuir probe amplifier calibration - D-11.

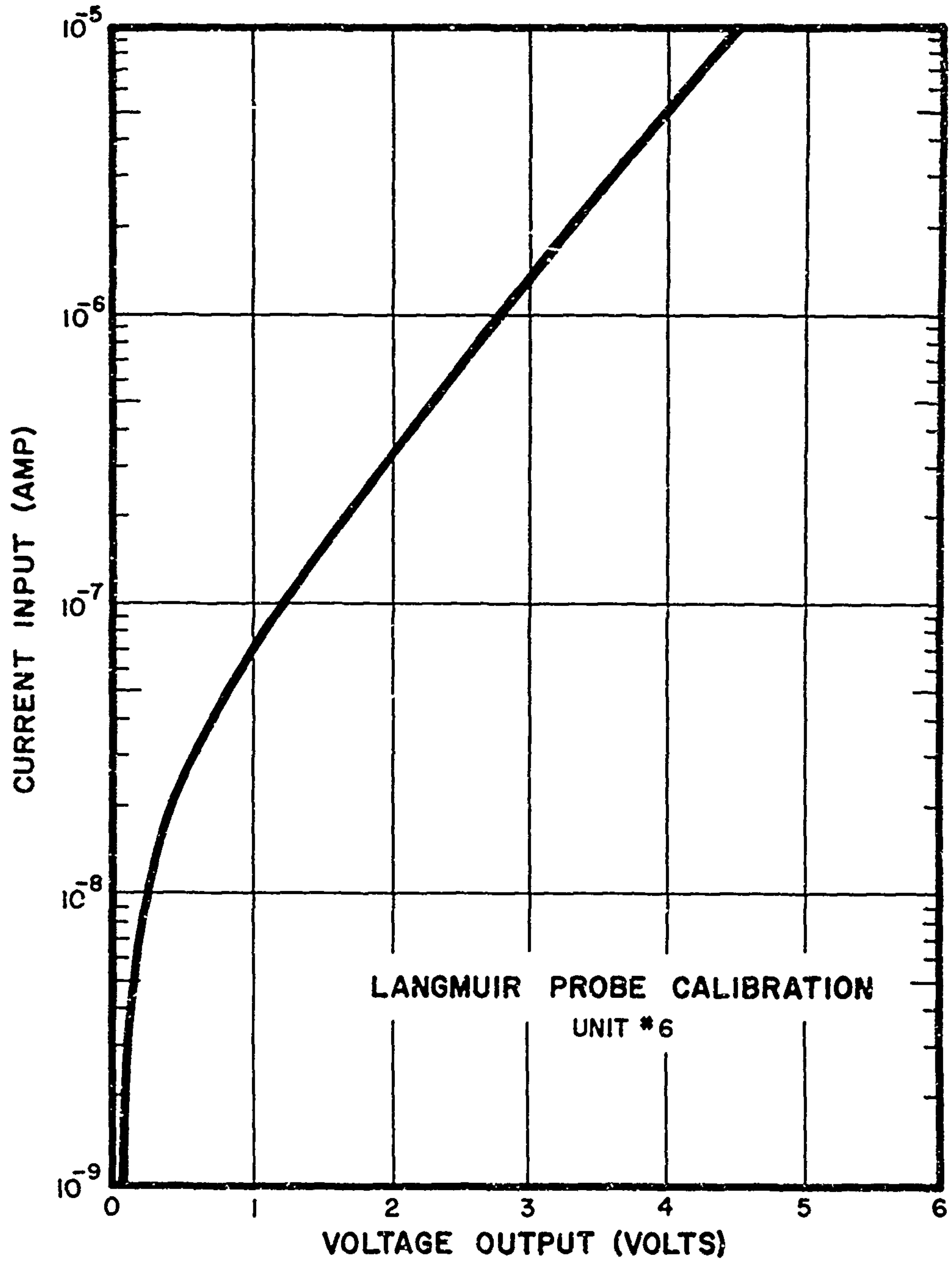


Fig. 13. Langmuir probe amplifier calibration - D-13.

Standing Wave Impedance Probe

The standing wave impedance probe has been flown extensively on sounding rockets and satellites for a number of years for measuring electron density [*Haycock et al.*, 1964; *Ulwick et al.*, 1965]. This technique measures the change in the impedance of a dipole antenna as the antenna moves through the ionosphere. A block diagram of the system is shown in Figure 14. RF signals at frequencies of 2 and 5 Mhz are alternately fed through the lumped-constant, artificial transmission lines to the antennas. A mechanical commutator samples the voltage on each segment of one transmission line, and this information is telemetered to ground. From the voltage standing wave on the antenna feed line, it is possible to determine the antenna impedance and hence the electron density. Some deviations from the standard impedance probe system as described by *Ulwick et al.* [1964] were made for the eclipse program.

Due to the planned rocket spin rate of 6 rps, a high data sample rate was desirable. This was accomplished by changing the 60-segment commutator format to non-return to zero, using an 18-rps motor, and sampling the line tap points in a different manner than used in previous flights. Twelve odd-numbered tap points of the line were sampled, followed by the twelve even segments. By repeating this sequence twice for each revolution of the 18-rps commutator, an effective rate of 72 data samples per second was accomplished. The commutator assignment is given in Table 4.

TABLE 4. Standing Wave Impedance Probe
Commutator Pin Assignments

Pin No.	Function	Pin No.	Function
1	0 cal	31	SWIP 24
2	+2.5 volt cal	32	Freq. Ind.
3	0 cal	33	SWIP 1
4	+5 volt cal	34	SWIP 3
5	0 cal	35	SWIP 5
6	+1 volt ref	36	SWIP 7
7	0 cal	37	SWIP 9
8	SWIP 1	38	SWIP 11
9	SWIP 3	39	SWIP 13
10	SWIP 5	40	SWIP 15
11	SWIP 7	41	SWIP 17
12	SWIP 9	42	SWIP 19
13	SWIP 11	43	SWIP 21
14	SWIP 13	44	SWIP 23
15	SWIP 15	45	SWIP 2
16	SWIP 17	46	SWIP 4
17	SWIP 19	47	SWIP 6
18	SWIP 21	48	SWIP 8
19	SWIP 23	49	SWIP 10
20	SWIP 2	50	SWIP 12
21	SWIP 4	51	SWIP 14
22	SWIP 6	52	SWIP 16
23	SWIP 8	53	SWIP 18
24	SWIP 10	54	SWIP 20
25	SWIP 12	55	SWIP 22
26	SWIP 14	56	SWIP 24
27	SWIP 16	57	Freq. Ind.
28	SWIP 18	58	Frame Sync.
29	SWIP 20	59	Frame Sync.
30	SWIP 22	60	Comm. Output

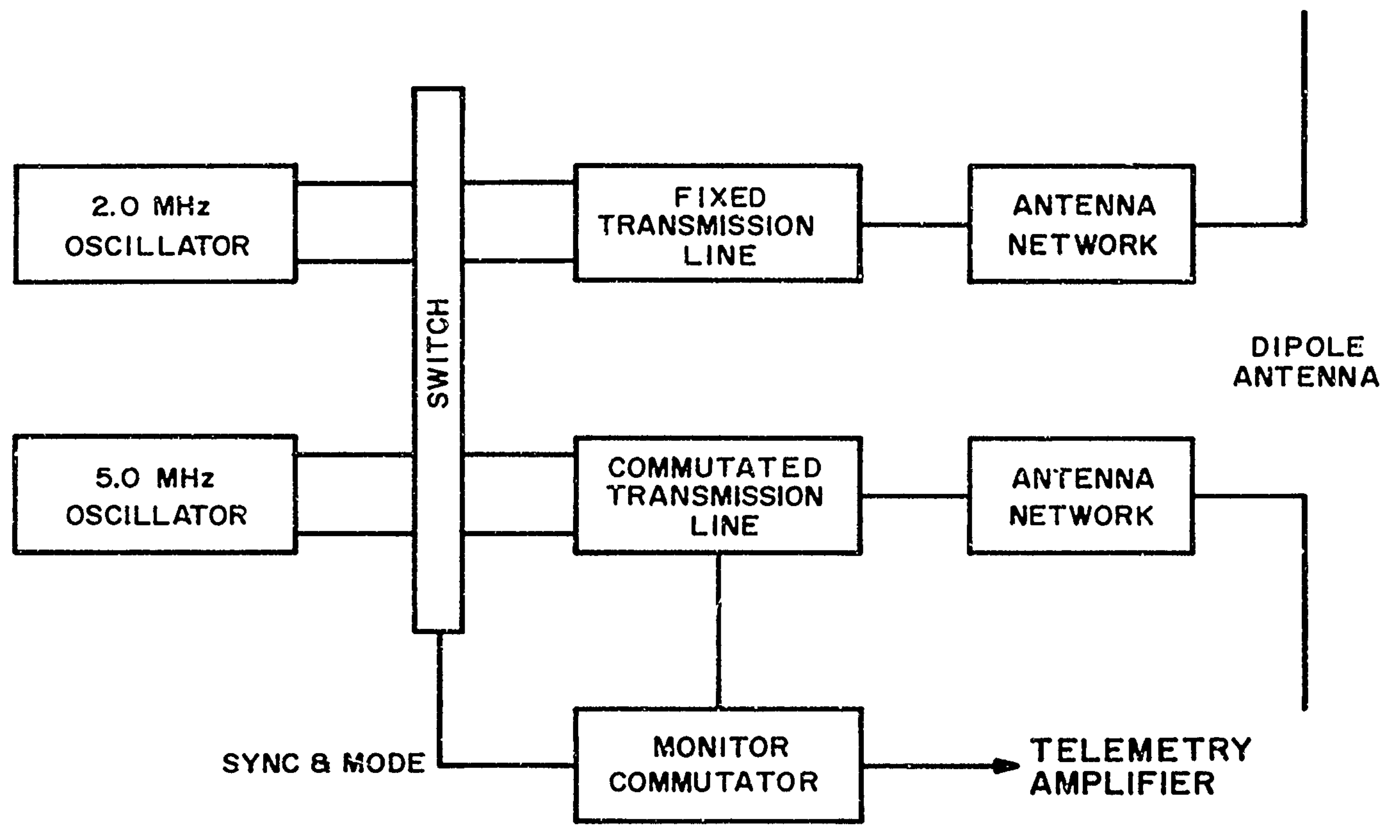


Fig. 14. Standing wave impedance probe block diagram.

The frequency switching circuits were designed to alternate the 2 and 5 Mhz oscillators with each revolution of the commutator. A countdown circuit activated a relay that disconnected the RF voltage from the antenna once every 16 revolutions.

The results from the certification round showed that the impedance probe changed the vehicle potential. This change in vehicle potential modified the output voltages of the dc probes aboard the rocket. The following field modifications were performed in order to obtain the maximum amount of data from all experiments:

1. The 10 K ohm resistors between the antennas and ground were removed on payloads D-11 and D-13 so that a comparison could be made with payload D-4 where the resistor was not removed.

2. The relays in the countdown circuit were rewired such that no RF was applied to the antenna for seven revolutions of the commutator. It was found that by critical adjustment, it was possible to apply RF to the antenna for two commutator revolutions, although the circuit was designed to switch for one revolution only. The 5-Mhz signal was sometimes lost since the adjustment was critical.

Schematic diagrams of the SWIP circuitry are shown in Figures 15 through 21. The calibration data are also included for the four impedance probes and are given in Appendix A.

Telemetry

The telemetry system of each rocket consisted of a single FM/FM transmitter operating at the carrier frequencies given in Table 5.

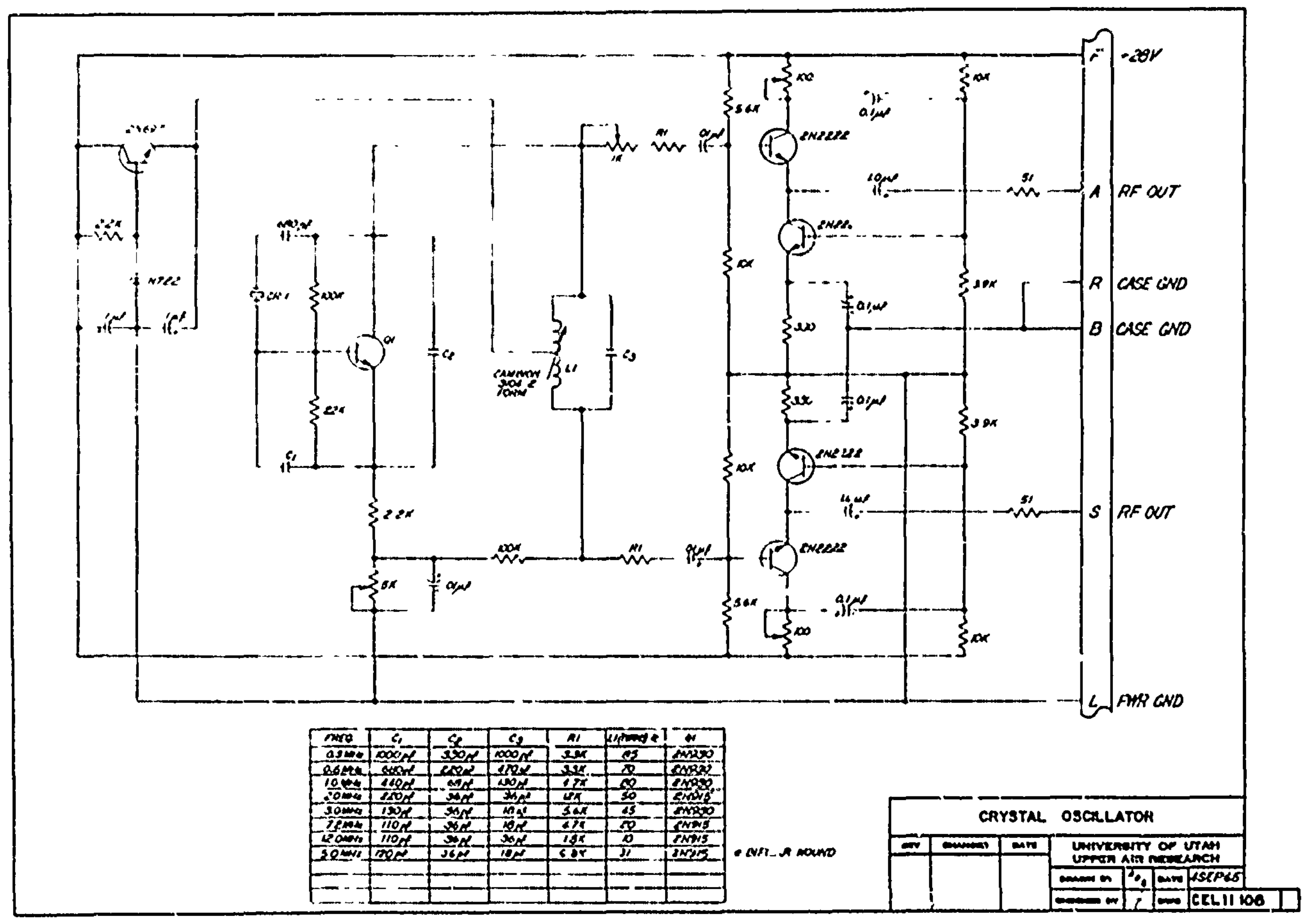


FIg. 15. Standing wave impedance probe oscillator.

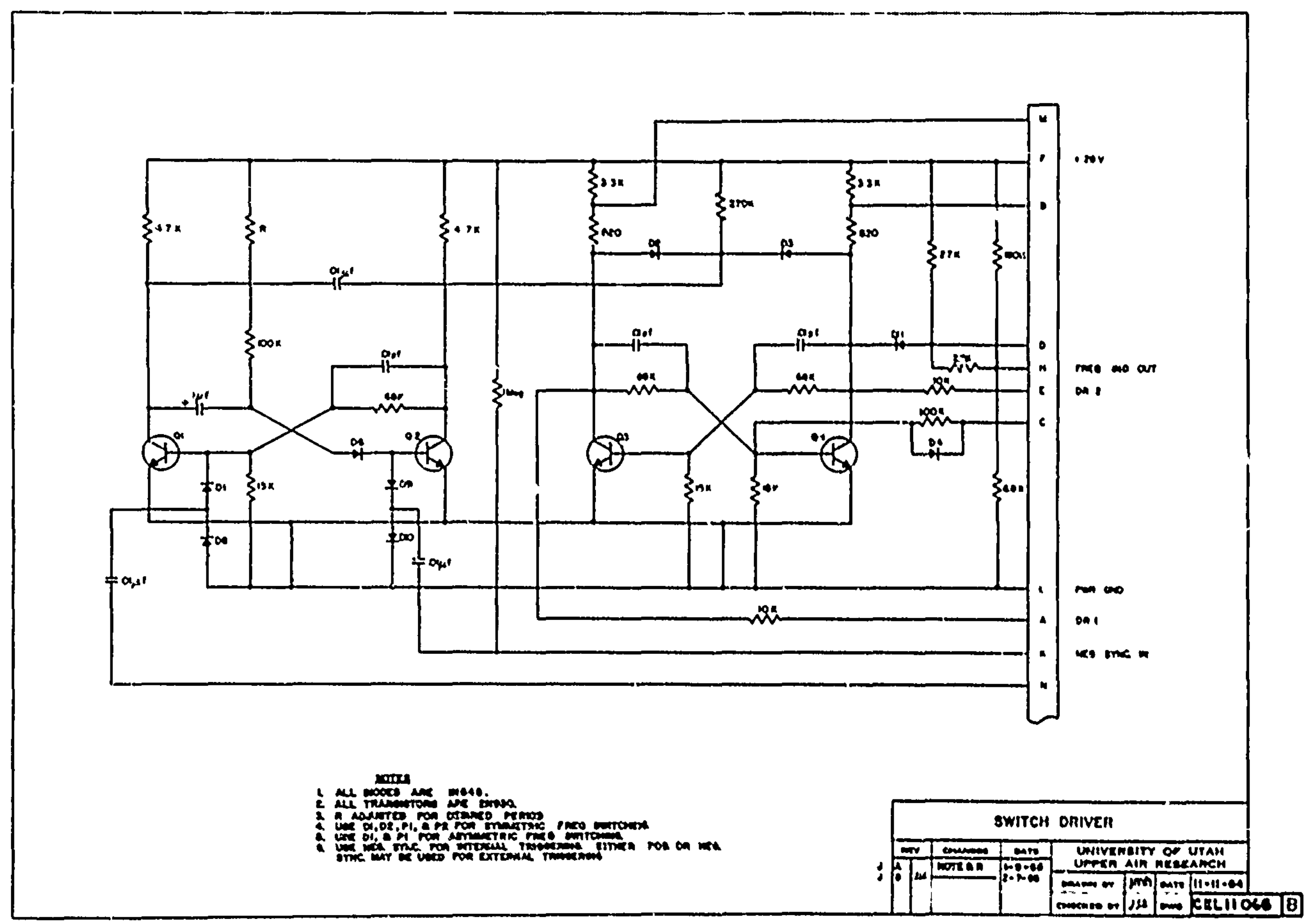


Fig. 16. Standing wave impedance probe switch driver.

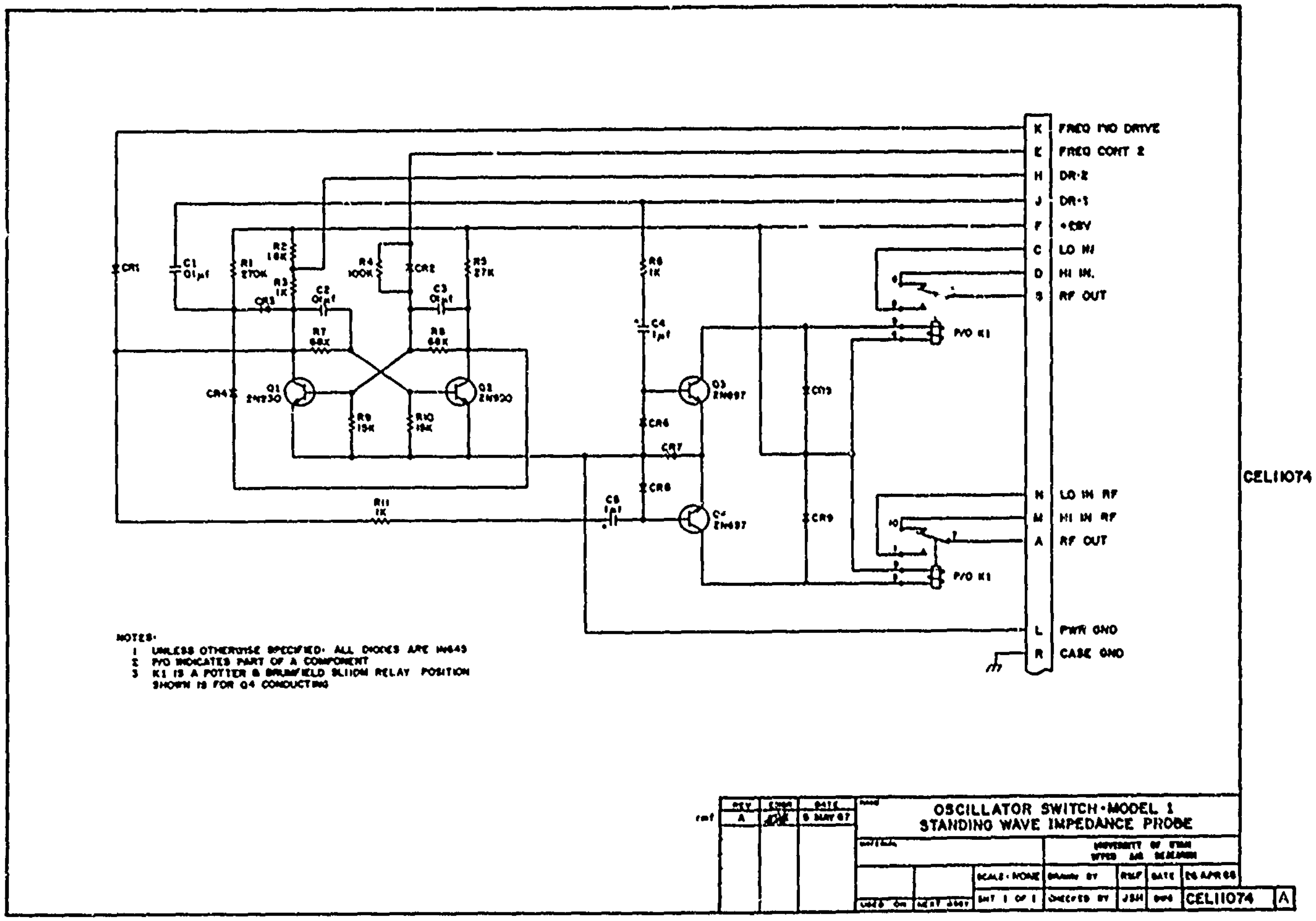


Fig. 17. Standing wave impedance probe oscillator switch.

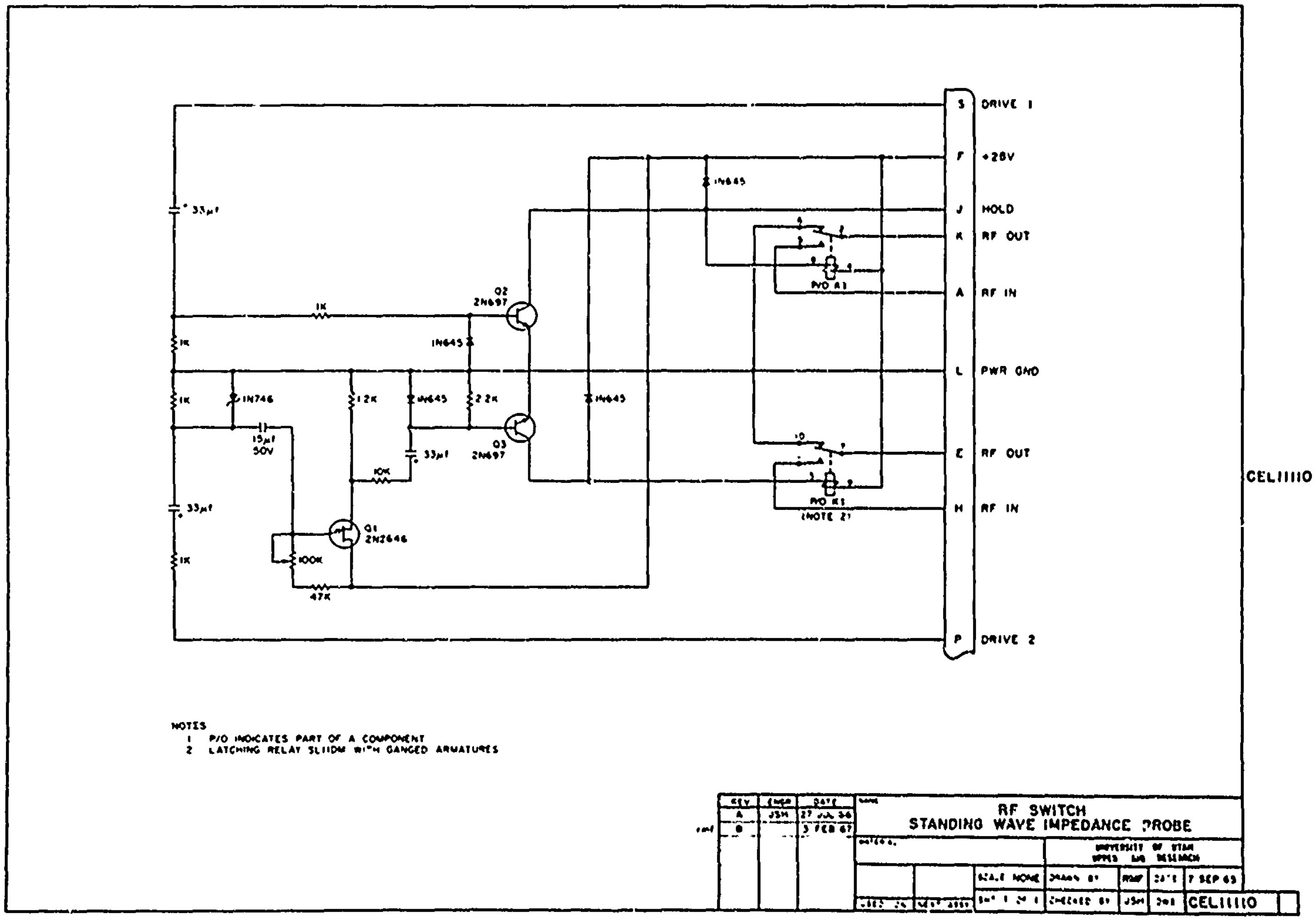
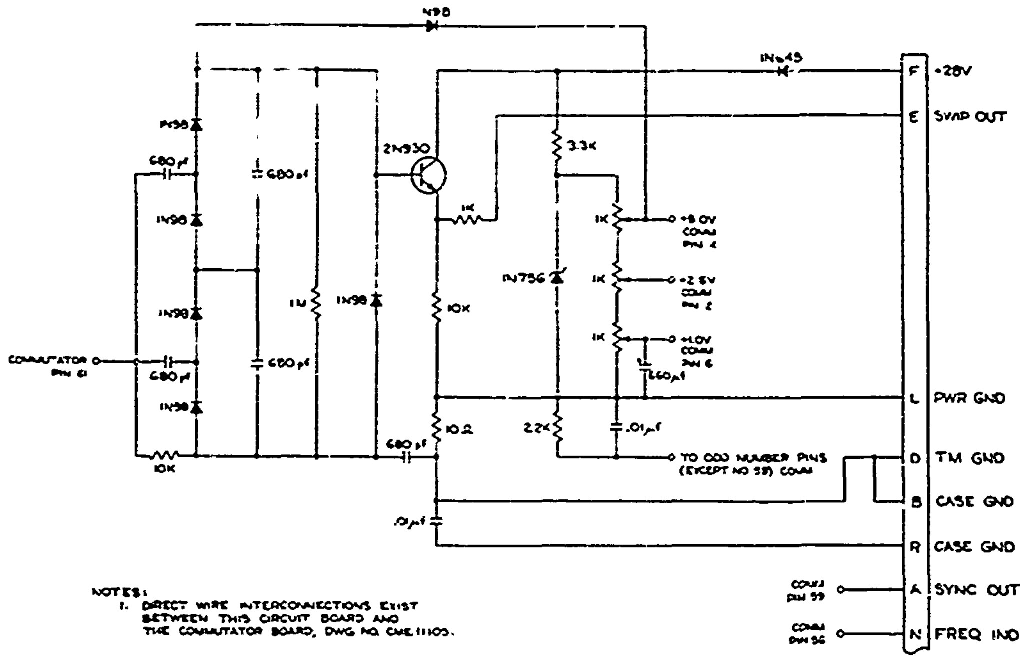
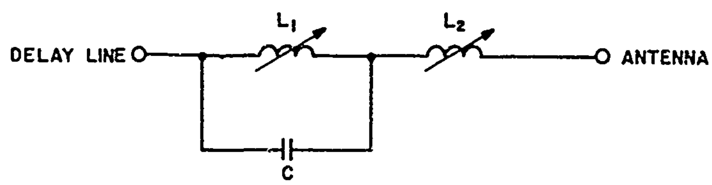


Fig. 18. Standing wave impedance probe RF switch.



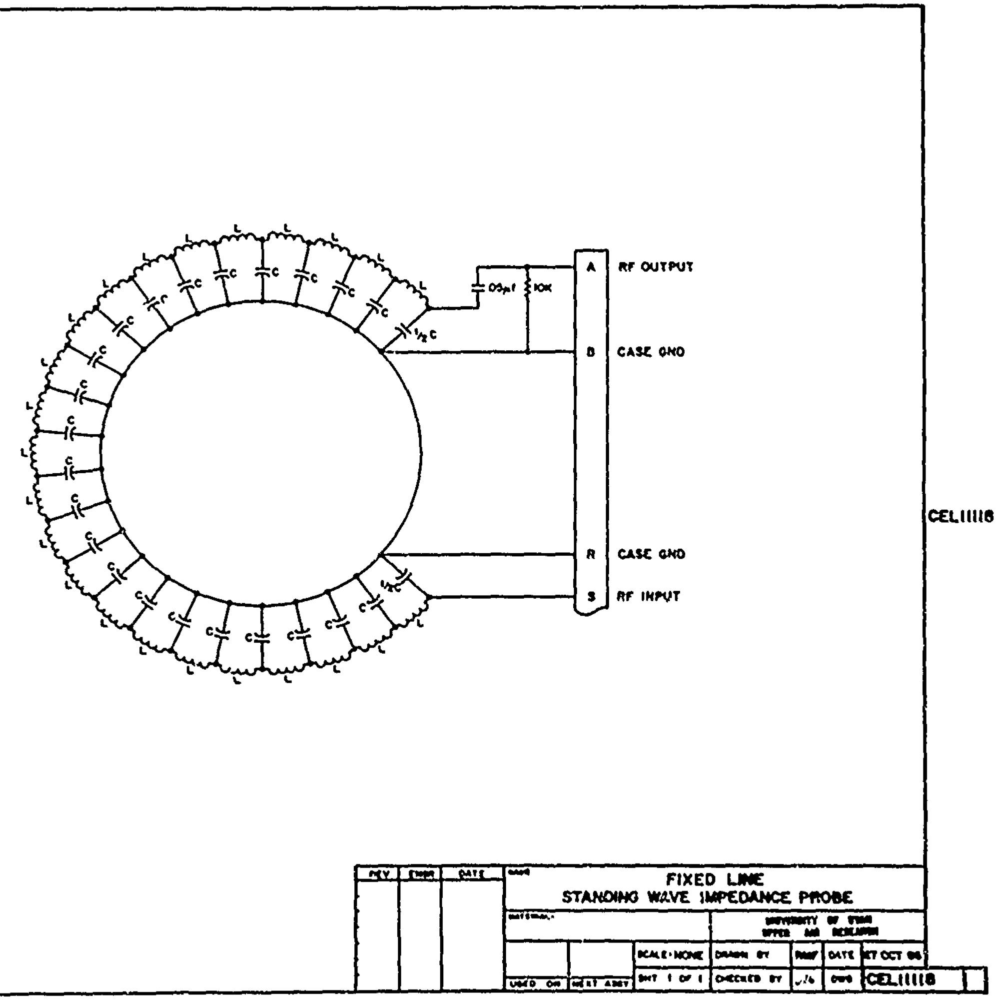
VOLTAGE REFERENCE
AND
QUADRUPLER—RECTIFIER



Notes:
The values of L_1, L_2, and C are chosen so that the sum of the reactances of the matching network and the antenna is +50 ohms.

MATCHING NETWORK

Fig. 19. Standing wave impedance probe voltage reference.



LINE FREQUENCY	NOMINAL VALUES	
	INDUCTORS (L)	CAPACITORS (C)
1 MHz	L_T = 32.2 μh, 23 SECT #30 HNC WIRE FORM .206" 16T/SECT	560 pf
2 MHz	L_T = 16.4 μh, 23 SECT #30 HNC WIRE FORM .115" 22T/SECT	271 pf
3 MHz	L_T = 10.84 μh, 23 SECT #32 HNC WIRE FORM .075" 28T/SECT	180 pf
3 MHz	L_T = 6.53 μh, 23 SECT #30 HNC WIRE FORM .075" 20T/SECT	110 pf
7.2 MHz	L_T = 4.53 μh, 23 SECT #28 HNC WIRE FORM .075" 17T/SECT	75 pf
5 MHz	L_T = 93 μh, 37 SECT #32 WIRE ON RED-BLU SMALL TOROID 51/SECT	1000 pf

Fig. 20. Standing wave impedance probe fixed line.

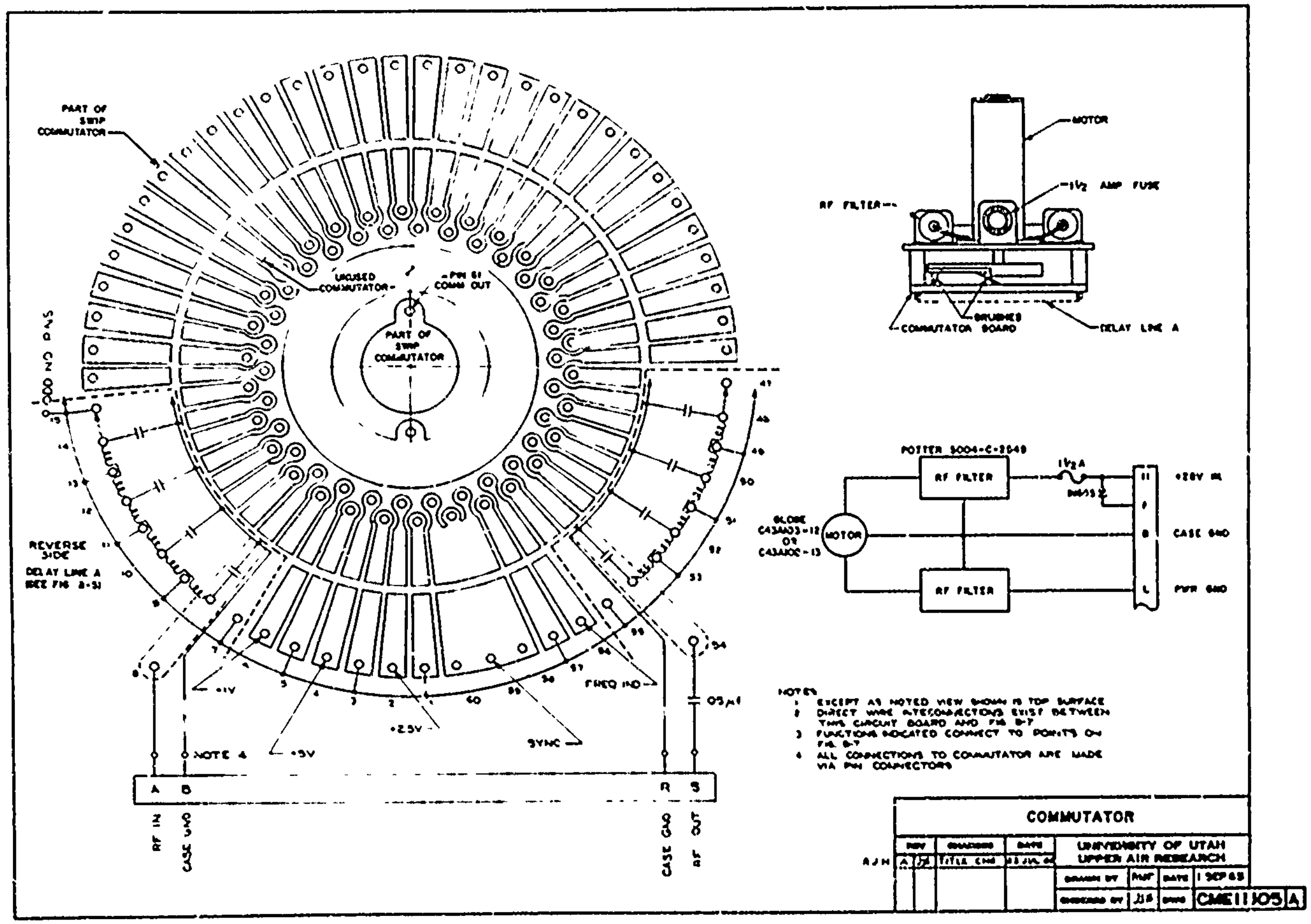


Fig. 21. Standing wave impedance probe commutator.

TABLE 5. Telemetry Carrier Frequency Assignments

Rocket Number	Carrier Frequency (Mhz)
Certification Round	255.1
D-4	255.1
D-11	258.5
D-13	252.4

The subcarrier assignments on the four payloads were identical and are given in Table 6. The 30 and 40 Khz channels were used only for range tracking.

TABLE 6. Telemetry Subcarrier Assignments

IRIG Band	Center Freq. (Khz)	Assignment	Input Voltage	
None	36 kc	Ranging rcvr. output	-	
4	960 cps	Gyro pitch	0 to 5	
5	1.3 kc	Ion trap status mon	0 to 5	
6	1.9 kc	Magnetometer roll	0 to 5	
7	2.3 kc	Mass spec. sweep	0 to 5	
8	3.0 kc	Lyman-α	0 to -5 0 to 5	Cert. Rnd. Eclipse
9	3.9 kc	ACS monitor	0 to 5	
10	5.4 kc	Monitor commutator	0 to 5	
11	7.35 kc	Mass spectrometer	0 to 5	
12	10.5 kc	Langmuir probe	-1.25 to 5	
13	14.5 kc	Ion trap	0 to 5	
14	22.0 kc	RPA	0 to 5	
17	52.5 kc	Gyro multiplexer	0 to 5	
18	70.0 kc	SWIP (STD)	0 to 5	
19	93.0 kc	Solar radiation	0 to 5	

The pin assignments for the four monitor commutators (IRIC Band 10) were identical and are given in Table 7.

TABLE 7. Monitor Commutator Pin Assignments

Function	Exp.	Excursion (volts)	Segment	
0 volt cal	PL		1	
DC sweep	MS		2, 13, 24, 35, 46, 56	
Vacuum	MS		3, 14, 25, 36, 47, 57	
Timer #1 ≈ 45 sec	PL	4 - 0	4	
Batt. P.M. 5	PL	≈3.3	5, 6	
Batt. P.M. 1	ACS	≈3.8	7	
Long. Mag.	PL		8, 34	
Receiver signal	PL		9	
Baro. mon.	PL	0 - 4	10, 40	
TI	RPA		11, 12	
Probe Mon. #1	RF		15	
Timer #2 ≈ 35 sec.	PL	0 - 4	16	
Timer #3 ≈ 3 sec.	PL	1 - 4	17	
Separation release	PL	1 - 4	18	
Squib #1 4-dr. ≈ 60 sec	PL	0 - 3	19	
Door release #1	PL	1 - 4	20	
Door release #2	PL	1 - 4	21	D-11 voltage
Door release #3	PL	1 - 4	22	change was 5 - 0.
Door release #4	PL	1 - 4	23	
Squib #2 4-dr. ≈ 61 sec.	PL	0 - 3	49	
Motor control ≈ 62 sec.	PL	0 - 3	26	
Boom deployment	Ion	0 - 4	27	
Boom deployment	RPA	0 - 4	28	
Squib 1 & 2 ≈ 75 sec.	MS Tip	0 - 3	29	
Squib 3 & 4 ≈ 77 sec.	MS Tip	0 - 3	30	
Tip release	MS	5 - 0	31	

TABLE 7. (Cont.)

Function	Exp.	Excursion (volts)	Segment
Squib #1 ≈ 65.5 sec	RF Ant	0 - 3	32
Squib #2 ≈ 65.5 sec	RF Ant	0 - 3	33
Ant deployment	Hi den RF	4 - 0	37 large
Ant deployment	SWIP RF	4 - 0	38 small
ACS ON ≈ 63 sec	ACS	0 - 4	39
Nozzle power	ACS		41
5 VDC mon	ACS		42
Receiver pressure	ACS		43
Reorient ON ≈ 140 sec	ACS	0 - 3.5	44
Probe mon #2	RF		45, 55
Internal & Pyro +28	Separation	0 - 4	48
High volt	MS		50
Int. bias	MS		51
Ext. bias	MS		52
Not used			53
Not used			54
+2.5 volt ref	PL		58
+5 volt	Frame sync		59, 60 master pulse

Payload Summary

Payload integration was performed by GCA Corporation. Preflight payload integration, interference, telemetry and vibration tests were performed at the Air Force Cambridge Research Laboratories. The position of the experiments in the assembled payload is shown in Figures 22 and 23. The location of the sensing elements for the various probes is shown in Figure 24.

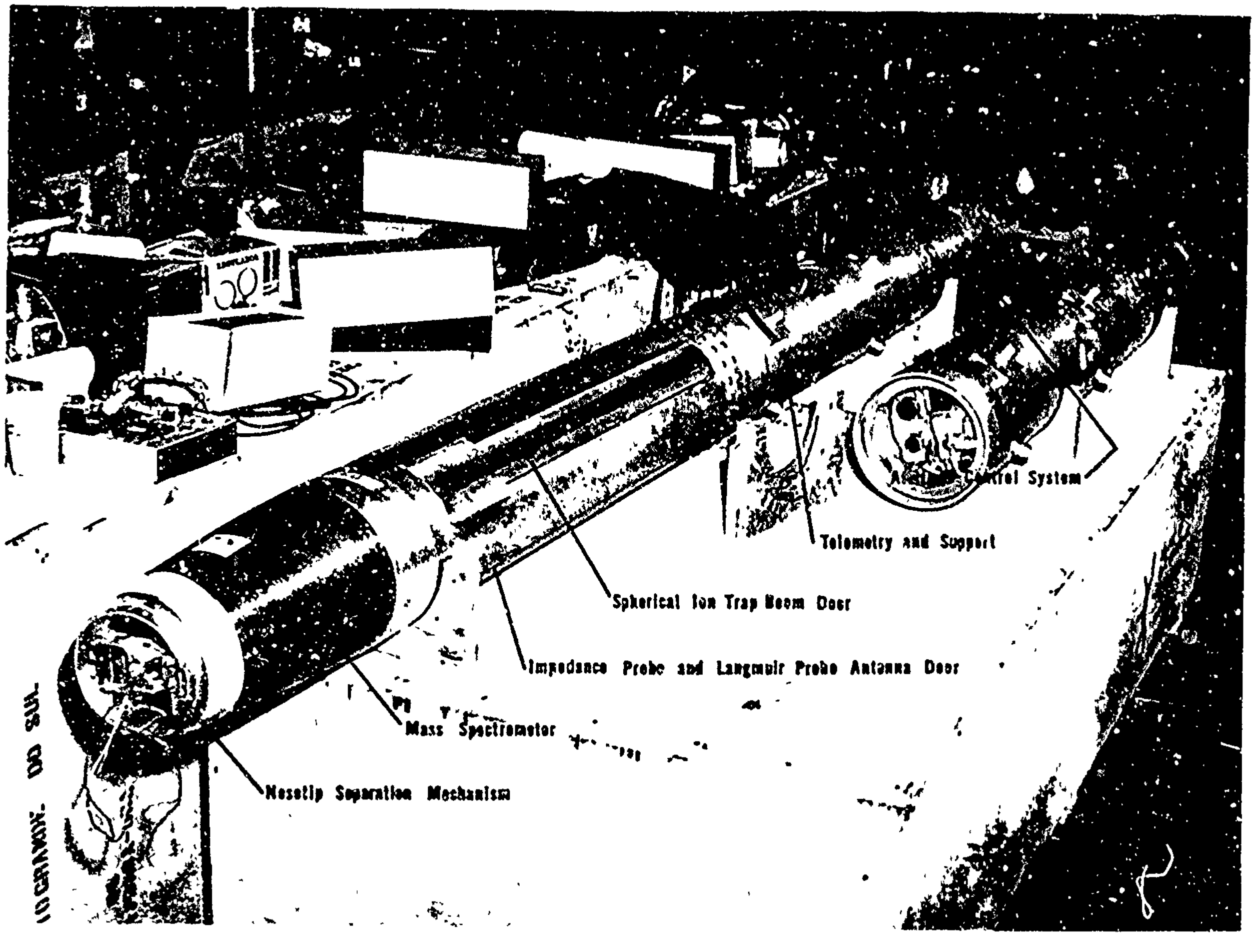


Fig. 22. Eclipse payload instrumentation section.

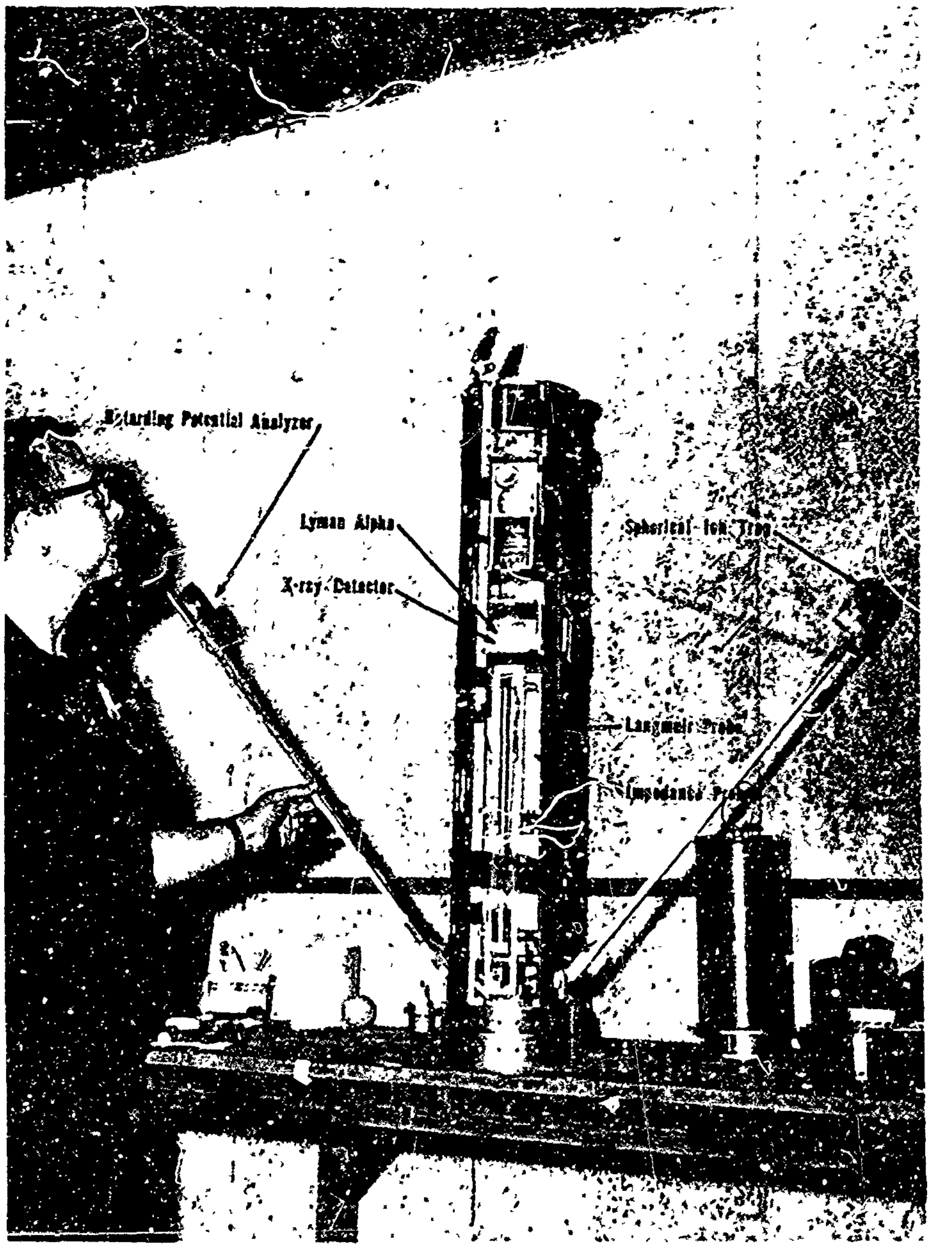


Fig. 23. Eclipse payload instrument orientations.

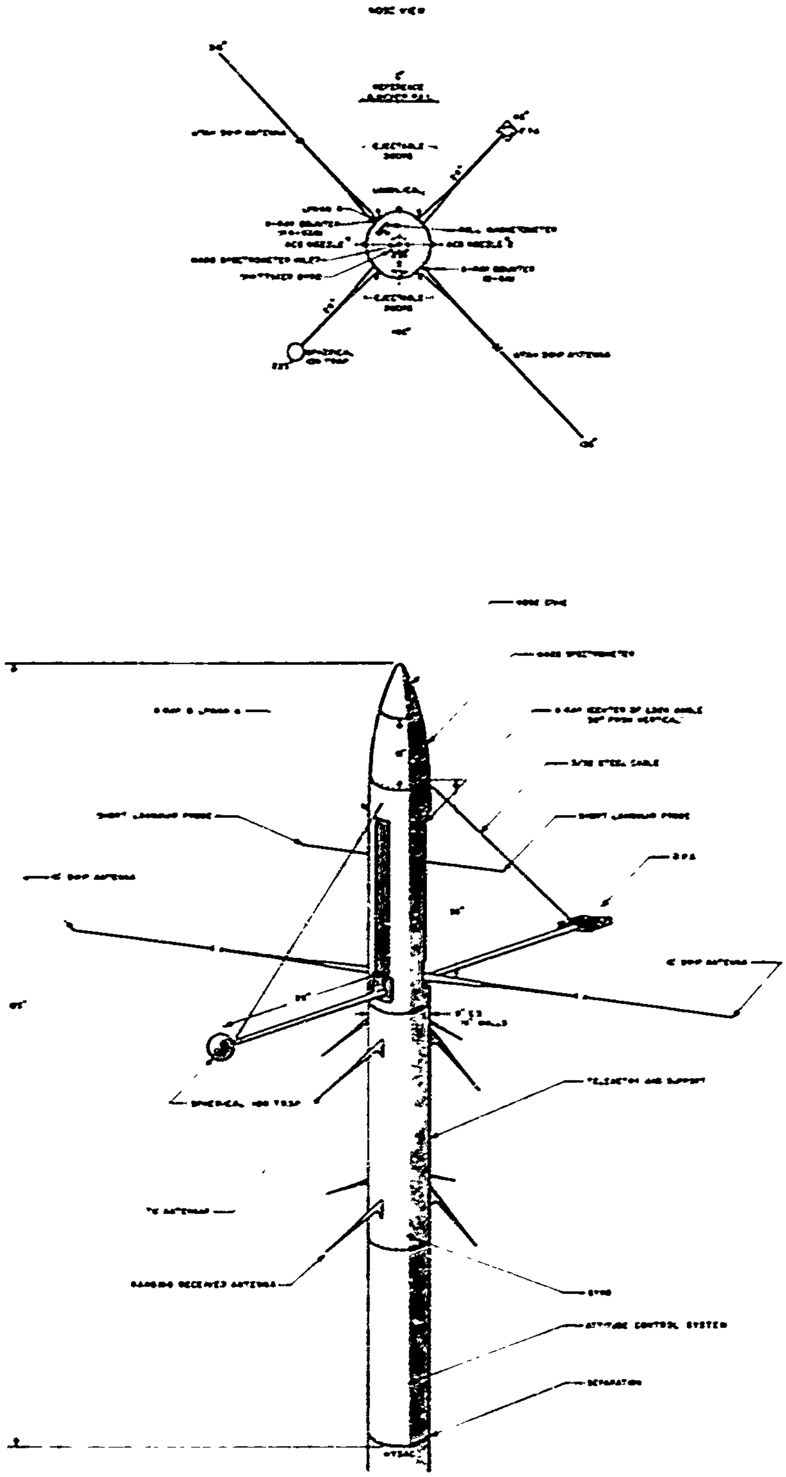


Fig. 24. Eclipse payload sensing probe locations.

The schedule for door release and boom deployment is tabulated in Table 8. The planned rocket flight program is shown in Figure 25. Figures 26 and 27 show the trajectory plots for rockets D-4, D-11, and D-13. The range data is referenced to the C[illegible]c tracking site.

TABLE 8. Payload Timer Function Sequence

Function	Time
Primary 4-door release	60 ± 1/2 sec
Secondary 4-door release	61 ± 1/2 sec
Probe release	65 ± 1/2 sec

The rocket assignment for the University of Utah instruments is given in Table 9.

TABLE 9. University of Utah Experiment Assignments

Rocket	SWIP Exp.	Hi den. housing & matching network	Standard housing & matching network	Tapped line mon	Langmuir probe
Cert. Round	NH-93	#103	#100	Hi density housing	#3
D-4	NH-97	#60 (2)	#61 (1)	Standard housing	#7
D-11	NH-96	#101	#102	"	#5
D-13	NH-95	#105	#104	"	#6

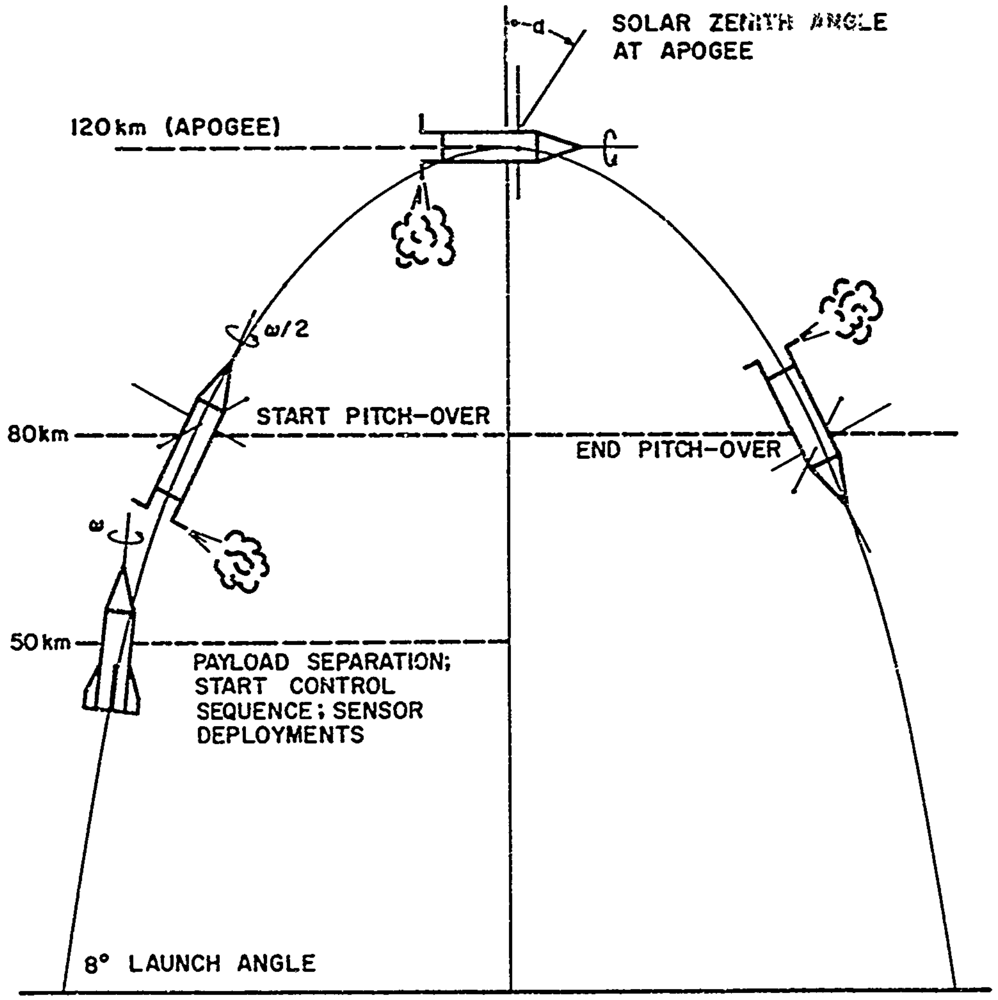


Fig. 25. Eclipse payload proposed flight control program.

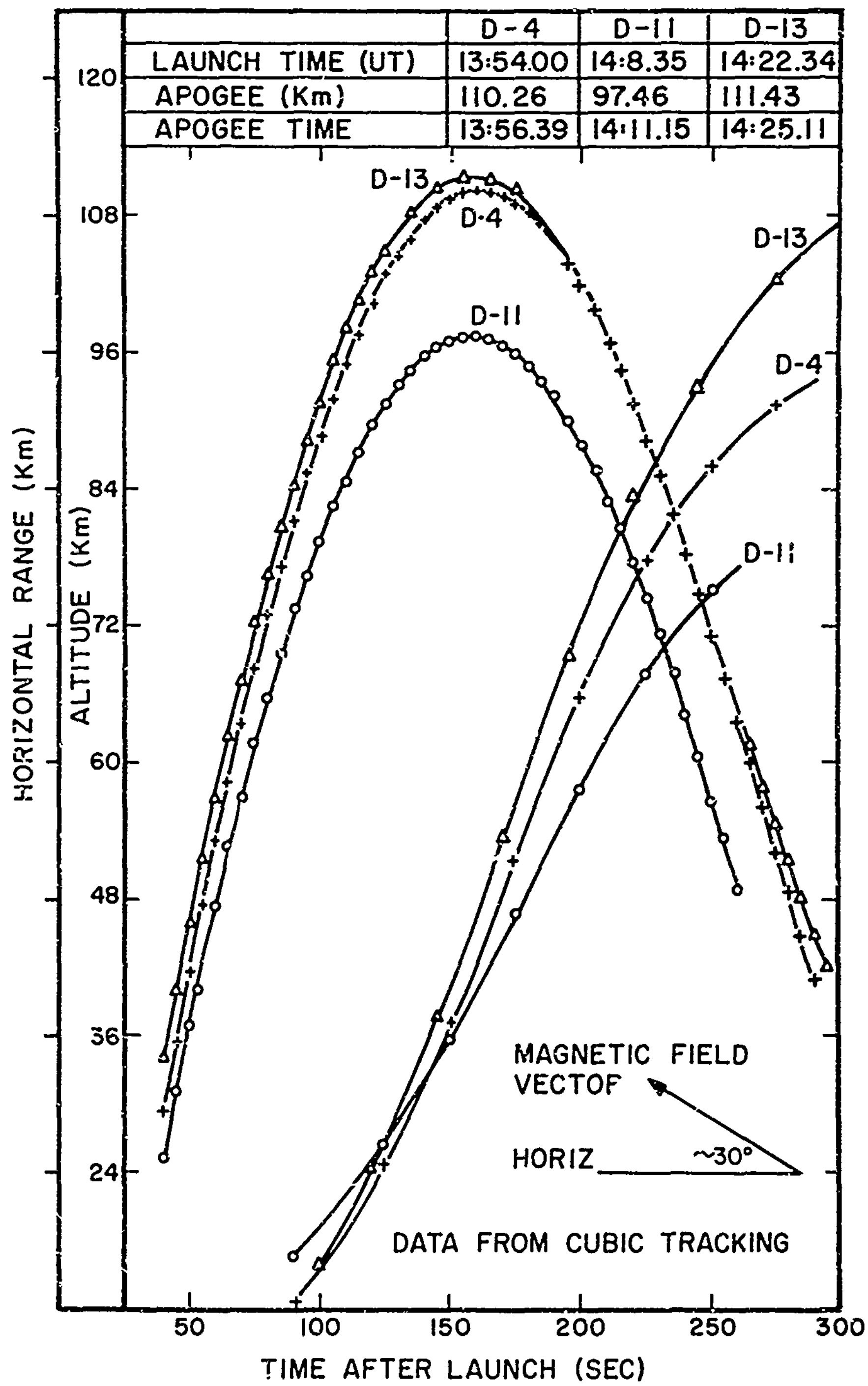


Fig. 26. Eclipse payload trajectory plots.

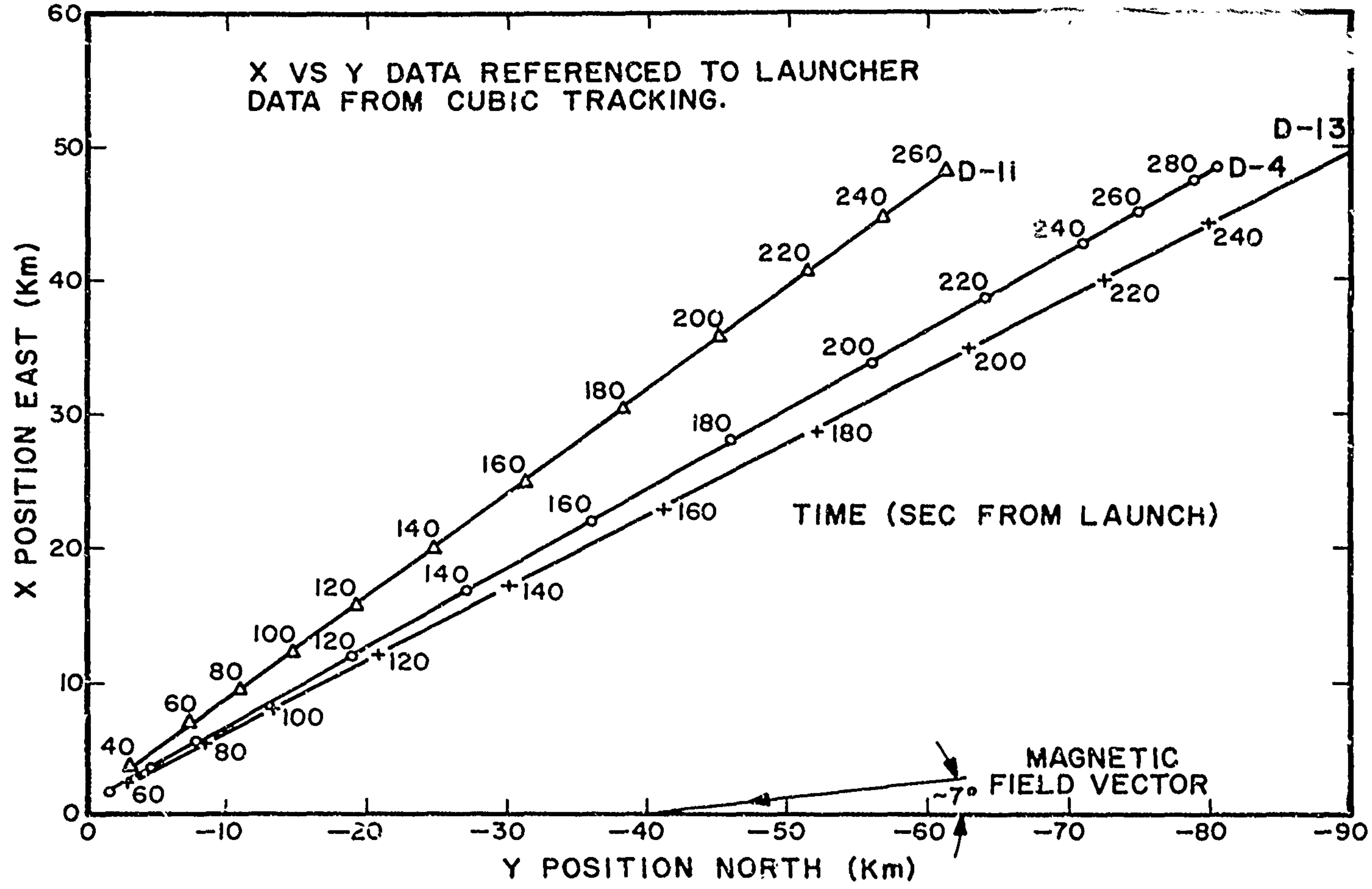


Fig. 27. Eclipse payload rocket X-Y positions.

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APPENDIX

Upper Air Research
Form No. 100A 44
Date 3 Aug. 1966

IMPEDANCE PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	DASA Certification	
Electronics Box Code No.	11112-NH-93	
Experiment Type	Comm. Line Balanced	
Experiment Frequencies	2.0 mc	5.0 mc
Corresponding Mode Voltages	.50	3.65
Line Z_o *	.54	49.5
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *	-	
R.F. Cable Information		

A. Type RG-188

B. Lengths Internal to Experiment Box 14 in.

C. Lengths External to Experiment Box 28 in.

D. Total Lengths 42 in.

II. CALIBRATION INFORMATION

A. Laboratory Checkout

1. Persons Responsible Hyatt
2. Date 4 Aug. 1966
3. Form of Calibration Data Visicorder
4. Present Data Location Upper Air Research Lab
5. Electronics Box Weight 3 lb. 14 oz.
6. Current Drain 310 ma Voltage 28

B. Field Checkout - Location ______

1. Persons Responsible ______
2. Date ______
3. Form of Calibration Data ______
4. Present Data Location ______

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load 470 K

B. Calibration Box

1. No. 2 (7.2 mc) For 5.0 MC

2. No. 1 (3.0 mc) For 2.0 MC

C. RF Voltage Level at Antenna Jacks

1. 1.5 VPP P.P. at 2.0 mc MC

2. 0.8 VPP P.P. at 5.0 mc MC

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.	
Fixed line	CEL 11075	FL-3-36
Comm. Ref. voltage	CEL 11106	RV-3-1
Motor board	CEL 11075	
Commutator		
Comm. line	CEL 11105	CL-3-128
RF switch M1	CEL 11110	
2 Mhz Osc. M3	CEL 11108	0-3-20
Osc Switch M1	CEL 11074	5-1-14
5 Mhz Osc M3	CEL 11108	0-3-22
Osc. Switch driver	CEL 11073	D-1-17 M1

Comments:

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11112-NH-93 Date 20 July 1966

Line No. CL-3-128 Operator Hyatt

Output Voltage from Generator 1.5

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ. 2 mc	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.375	.995	1.43	.975	.	.
2	1.30	.995	1.50	.97	.	.
3	1.20	.99	1.475	.95	.	.
4	1.08	.98	1.34	.94	.	.
5	.905	.98	1.10	.93	.	.
6	.82	.975	.77	.925	.	.
7	.67	.97	.373	.92	.	.
8	.501	.97	.146	.92	.	.
9	.342	.96	.502	.92	.	.
10	.185	.955	.88	.92	.	.
11	*.072	.950	1.19	.92	.	.
12	.185	.945	1.40	.92	.	.
13	.344	.94	1.50	.92	.	.
14	.50	.94	1.49	.92	.	.
15	.66	.93	1.37	.92	.	.
16	.81	.925	1.14	.91	.	.
17	.95	.92	.82	.905	.	.
18	1.075	.92	.420	.90	.	.
19	1.19	.92	* .05	.90	.	.
20	1.29	.92	.420	.90	.	.
21	1.37	.92	.82	.895	.	.
22	1.43	.92	1.14	.89	.	.
23	1.48	.92	1.37	.88	.	.
24	1.50	.92	1.49	.875	.	.

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11112-NH-93 Date 25 JULY 1966

Line No. FL-3-36 Operator Hyatt

Output Voltage from Generator 1.5

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.36	.975	1.475	.97		
2	1.28	.975	1.50	.955		
3	1.18	.97	1.47	.945		
4	1.06	.97	1.34	.93		
5	.94	.96	1.09	.92		
6	.80	.955	.76	.92		
7	.65	.955	.359	.91		
8	.50	.95	.145	.91		
9	.338	.95	.50	.91		
10	.178	.945	.88	.925		
11	* .07	.945	1.18	.925		
12	.178	.94	1.39	.93		
13	.335	.93	1.49	.94		
14	.50	.925	1.48	.94		
15	.65	.92	1.37	.94		
16	.80	.92	1.15	.925		
17	.94	.92	.825	.92		
18	1.06	.91	.428	.91		
19	1.175	.91	* .06	.905		
20	1.275	.91	4.28	.90		
21	1.35	.905	.82	.89		
22	1.42	.905	1.15	.89		
23	1.46	.905	1.37	.88		
24	1.49	.905	1.475	.875		

* Maximum or minimum voltage on the line

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11112-NH-93 Date 20 June 1966

Line No. CL-3-128 Operator Hyatt

Calibration Check Freq.	2 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 17.4+j176 17.4+j176	* 17.4+j174 17.4+j174	* 11.2-j285 j	* 11-j288 j	* j j	* j j
Z Short Circuit	* 4.2-j65 4.3 j65	* 4.0-j64 4.3-j64	* 11.6+j240 j	* 11.8+j243 j	* j j	* j j
Z_{50} ohm	* 51-j5 51-j5	* 50-j7 50-j7	* 50-j12 j	* 51-j12 j	* j j	* j j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 54.2 $\angle 2°$	j 52.5 $\angle -2.1°$	j 49.8 $\angle -1.3°$	j 50.3 $\angle -1.5°$	j	j
$\gamma_d = 1/2 \ln \frac{Z_o+Z_{sc}}{Z_o-Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11112-NH-93 Date 20 June 1966

Line No. FL-3-36 Operator Hyatt

Calibration Check Freq.	2 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 16.6+j176 j	* 16.9+j172 j	* 11.3-j278 j	* 11.2-j285 j	* j j	* j j
Z Short Circuit	* 4.1-j61 j	* 4.1-j60 j	* 11.6+j250 j	* 12.5+j258 j	* j j	* j j
Z_{50} ohm	50.5-j2 * j	50- j4 * j	51-j3 * j	52-j13* j	j * j	j * j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	52.4 $\angle$-1.5° j AVE = 51.9	51.4 $\angle$-3.3° j	50 $\angle$-1.05° j AVE = 50.8	51.6 $\angle$-1.7° j	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11112-NH-93 Date 22 June 1966

Line No. CL-3-128 Operator Hyatt

Output Voltage from Generator 1.5 volts

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
	SHORT	50 Ω	SHORT	50 Ω		50 Ω
1	1.08	.	.745	.	.	.
2	1.26	.	.30	.	.	.
3	1.43	.	.385	.	.	.
4	1.59	.	.875	.	.	.
5	1.72	.	1.32	.	.	.
6	1.86	.	1.65	.	.	.
7	1.95	.	1.86	.	.	.
8	2.02	.	1.91	.	.	.
9	2.06	.	1.81	.	.	.
10	* 2.08	.	1.57	.	.	.
11	2.06	.	1.16	.	.	.
12	2.02	.	.74	.	.	.
13	1.95	.	.225	.	.	.
14	1.86	.	.358	.	.	.
15	1.73	.	.875	.	.	.
16	1.60	.	1.325	.	.	.
17	1.45	.	1.69	.	.	.
18	1.29	.	1.91	.	.	.
19	1.11	.	1.99	.	.	.
20	.92	.	1.91	.	.	.
21	.71	.	1.69	.	.	.
22	.480	.	1.325	.	.	.
23	.255	.	.875	.	.	.
24	.05	.	.41	.	.	.

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11112-NH-93 Date 23 June 1966

Line No. FL-3-36 Operator Hyatt

Output Voltage from Generator 1.5 volts

PIN NO. (Numbered from osc end)	FREQ. 2 mc SHORT	FREQ. 2 mc 50 Ω	FREQ. 5 mc SHORT	FREQ. 5 mc 50 Ω	FREQ. ___	FREQ. ___ 50 Ω
1	1.08	.	.76	.	.	.
2	1.27	.	.32	.	.	.
3	1.44	.	.375	.	.	.
4	1.61	.	.86	.	.	.
5	1.75	.	1.28	.	.	.
6	1.88	.	1.61	.	.	.
7	1.98	.	1.82	.	.	.
8	2.04	.	1.88	.	.	.
9	2.08	.	1.78	.	.	.
10	* 2.10	.	1.53	.	.	.
11	2.08	.	1.16	.	.	.
12	2.04	.	.73	.	.	.
13	1.98	.	.235	.	.	.
14	1.88	.	.324	.	.	.
15	1.75	.	.84	.	.	.
16	1.61	.	1.25	.	.	.
17	1.44	.	1.64	.	.	.
18	1.25	.	1.88	.	.	.
19	1.10	.	* 1.95	.	.	.
20	.90	.	1.88	.	.	.
21	.68	.	1.64	.	.	.
22	.46	.	1.25	.	.	.
23	.224	.	.86	.	.	.
24	.0	.	.385	.	.	.

* Maximum or minimum voltage on the line

109-4/65

ANTENNA MEASUREMENTS

Date Recorded 25 August 1966

By Marvin L. Higgins

Vehicle: Type Nike Hydac

Number #100: Cert. Rnd. #101: D-11 (Tapped Line)

Diameter 9 inches

Length 10 feet

Irregularities Both nose tip and the rocket are removed, leaving the 10 foot long right circular cylinder.

System: Balanced X Unbalanced

Antenna: Type Telescoping Ralph

Length

Detailed Description (Material, wire diameter, etc.):

Mounting: Type

Standard [ ] Not Standard [ ]

Position: Distance from Nose to Antenna Center 48 inches

If not centered, explain

Antenna Cable Length 6 5/8 inches

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 2.0 Mhz, 5.0 Mhz

Approved By

112-7/66

Impedance Data:

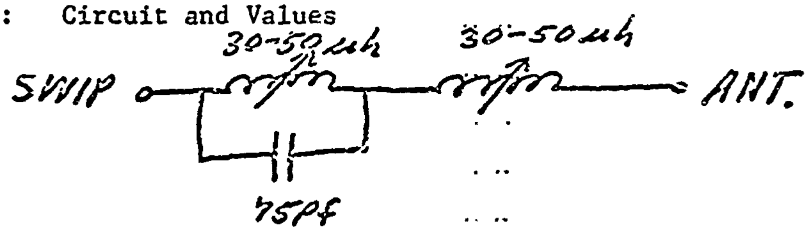
Cridinal data recorded in Notebook 263 Marvin L. Higgins
No. Name

Page 20 Date 23 August 1966

Frequency in MC	Corrected Impedance (Ant. shunt capacitance included)	
	#100	#101
1.0	0-j2898	0-j2848
2.0	0-j1455	0-j1267
3.0	0-j969	0-j944
5.0	0-j568	0-j560
7.2	0-j385	0-j377
12.0	[illegible]	[illegible]

Shunt Capacitance: 24.4 pf.

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency	Impedance	
	#100	#101
2.0	28.4+j50.3	27.1+j50.2
5.0	20.7+j49.7	20.8+j49.4

Upper Air Research
Form No. 100A
Date 22 Aug. 1966

IMPEDANCE PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	Solar Eclipse D-4	
Electronics Box Code No.	11116-NH-97	
Experiment Type	Balanced Comm. Line	
Experiment Frequencies	2.0 mc	5.0 mc
Corresponding Mode Voltages	1.01	4.38
Line Z_o *	53	49
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *		
R.F. Cable Information		

A. Type RG-188
B. Lengths Internal to Experiment Box 14"
C. Lengths External to Experiment Box 28"
D. Total Lengths 42"

II. CALIBRATION INFORMATION

A. Laboratory Checkout

1. Persons Responsible Hyatt
2. Date 22 August 1966
3. Form of Calibration Data Visicorder
4. Present Data Location Upper Air Research Labs
5. Electronics Box Weight 3 lb. 12 oz.
6. Current Drain 235 ma Voltage 28

B. Field Checkout - Location ____

1. Persons Responsible ____
2. Date ____
3. Form of Calibration Data ____
4. Present Data Location ____

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

Upper Air Research
Form No. 100A
Date 22 Aug. 1966

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load 470 k

B. Calibration Box

1. No. 1 (3 mc) For 2.0 MC

2. No. 2 (7.2 mc) For 5.0 MC

C. RF Voltage Level at Antenna Jacks

1. 3.0 P.P. at 2.0 MC

2. 2.1 P.P. at 5.0 MC

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.	
Fixed line	11075	FL-3-135
REF Voltage	11106	"
Comm. line	11105	CL-3-134
RF switch M1	11110	
2 mc osc. M3	11108	
Osc. switch M1	11074	
5 mc osc. M3	11108	
Osc. sw. driver	11073	

Comments:

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-97 Date 17 Aug. 1966

Line No. CL-3-134 Operator Erickson

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.30	.72	1.22	.77		
2	1.14	.72	1.28	.77		
3	1.07	.72	1.28	.76		
4	.97	.72	1.19	.75		
5	.86	.72	1.03	.74		
6	.73	.71	.77	.73		
[illegible]	.60	.71	.43	.73		
8	.46	.70	* .11	.72		
9	.31	.70	.43	.72		
10	.17	.70	.77	.72		
11	* .07	.69	1.03	.72		
12	.17	.69	1.19	.72		
13	.31	.68	1.28	.72		
14	.46	.68	1.28	.73		
15	.60	.67	1.19	.73		
16	.73	.67	1.03	.73		
17	.85	.67	.76	.72		
18	.96	.66	.41	.72		
19	1.05	.66	.07	.72		
20	1.12	.66	.42	.72		
21	1.19	.66	.77	.71		
22	1.24	.66	1.03	.70		
23	1.17	.66	1.20	.70		
24	1.28	.66	1.28	.69		

* Maximum or minimum voltage on the line

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-97 Date 17 Aug. 1966

Line No. FL-3-135 Operator Erickson

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.22	.73	1.23	.75		
2	1.15	.73	1.29	.74		
3	1.07	.73	1.28	.73		
4	.98	.73	1.20	.73		
5	.87	.72	1.03	.72		
6	.75	.72	.76	.70		
[illegible]	.61	.71	.41	.70		
8	.47	.71	.12	.69		
9	.32	.70	.46	.69		
10	.17	.70	.80	.69		
11	* .07	.69	1.05	.70		
12	.17	.69	1.22	.70		
13	.32	.68	1.30	.71		
14	.47	.68	1.28	.71		
15	.61	.68	1.20	.71		
16	.74	.67	1.03	.71		
17	.87	.67	.76	.72		
18	.97	.67	.42	.72		
19	1.07	.67	* .07	.71		
20	1.14	.67	.42	.70		
21	1.21	.66	.75	.70		
22	1.26	.66	1.02	.70		
23	1.29	.66	1.18	.70		
24	1.30	.65	1.27	.70		

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-97 Date 17 August 1966

Line No. CL-3-134 Operator Hyatt

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 9.7+j100 j	* 9.5+j97 j	* 9.7−j232 j	* 9.5−j235 j	* j j	* j j
Z Short Circuit	* 5.9−j92 j	* 5.5−j89 j	* 14.8+j300 j	* 15.5+j300 j	* j j	* j j
Z_{50} ohm	52−j4 * j	50−j7 * j	50−j14* j	50−j18* j	j * j	j * j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 54.0 $\angle -1.6°$	j 52.2 $\angle -1.8°$	j 50.4 $\angle -1°$	j 50.7 $\angle 1.6°$	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-97 Date 17 August 1966

Line No. FL-3-135 Operator Hyatt

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	9.2+j97 * j	9.0+j92 * j	10.4-j261 * j	10.1-j263 * j	* j j	* j j
Z Short Circuit	5.9-j96 * j	5.4-j92 * j	12+j255 * j	12.5+j253 * j	* j j	* j j
Z_{50} ohm	.52-j4 * j	49.5-j8 * j	49-j19 * j	49-j21 * j	* j j	* j j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 54.3 ∠-1.7°	j 51.8 ∠-2	j 49.0 ∠-.8	j 49.1 ∠1.5	j	j
$\gamma_l = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

ANTENNA MEASUREMENTS

Date Recorded July 13, 1966

By Rulon K. Linford

Vehicle:

Type Nike Hydac

Number D-4 #2 to tapped line

Diameter 9 inches

Length 10 feet

Irregularities Both the nose tip and the rocket are removed leaving the 10 foot long right circular cylinder

System: Balanced [X] Unbalanced [ ]

Antenna:

Type Telescoping Ralph

Length 9 feet

Detailed Description (Material, wire diameter, etc.):

Standard

Mounting:

Type Telescoping Ralph

Standard [X] Not Standard [ ]

Position: Distance from Nose to Antenna Center 48 inches

If not centered, explain

Antenna Cable Length 6 1/8 inches

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 2.0, 5.0 Mc

Approved By

112-7/66

Impedance Data:

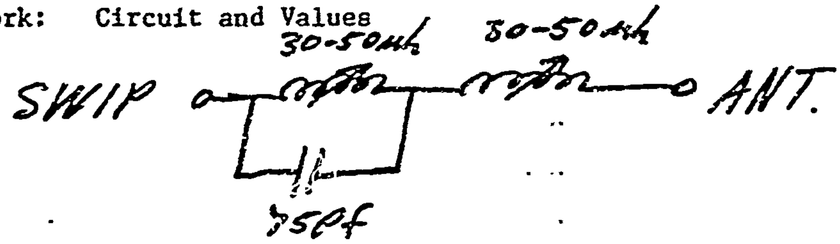
Oridinal data recorded in Notebook 234 Rulon K. Linford
No. Name

Page 36 Date August 3, 1966

Frequency in MC	Corrected impedance (Ant. shunt capacitance included)
1.0	0-j3725
2.0	0-j1887
3.0	0-j1235
5.0	0-j691.0
7.2	0-j488.5
12.0	0-j257.0

Shunt Capacitance: 17.4 pf.

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency	#1 Impedance	#2
2.0	34.6+j50.0	36.3+j50.2
5.0	22.9+j49.7	24.7+j50.5

Upper Air Research
Form No. 100A
Date 22 Aug. 1966

IMPEDANCE PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	Solar Eclipse D-11	
Electronics Box Code No.	11116-NH-96	
Experiment Type	Balanced Comm. Line	
Experiment Frequencies	2.0 mc	5.0 mc
Corresponding Mode Voltages	1.02	4.39
Line Z_0 *	52.5	51
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *		
R.F. Cable Information		

A. Type RG-188

B. Lengths Internal to Experiment Box 14"

C. Lengths External to Experiment Box 28"

D. Total Lengths 42"

II. CALIBRATION INFORMATION

A. Laboratory Checkout

1. Persons Responsible Hyatt
2. Date 22 August 1966
3. Form of Calibration Data Visicorder
4. Present Data Location Upper Air Research Labs
5. Electronics Box Weight 3 lb. 12 oz.
6. Current Drain 240 ma Voltage 28

B. Field Checkout - Location ____

1. Persons Responsible ____
2. Date ____
3. Form of Calibration Data ____
4. Present Data Location ____

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load 470 k

B. Calibration Box

1. No. 1 (3 mc) For 2.0 MC

2. No. 2 (7.2 mc) For 5.0 MC

C. RF Voltage Level at Antenna Jacks

1. 2.25 P.P. at 2.0 MC

2. 2.25 P.P. at 5.0 MC

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.	
Fixed line	11075	FL-3-43
Ref. voltage	11106	
Comm. line	11105	CL-3-133
RF switbh M1	11110	
2 mc osc. M3	11108	
Osc. switch M1	11074	
5 mc osc. M3	11108	
Osc. sw. driver	11073	

Comments:

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-96 Date 18 Aug. 1966

Line No. CL-3-133 Operator Erickson

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 3 mc		FREQ. 5 mc		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.23	.73	1.22	.77		
2	1.16	.73	1.28	.76		
3	1.08	.73	1.27	.74		
4	.99	.73	1.18	.73		
5	.88	.72	1.02	.71		
6	.76	.72	.77	.70		
7	.62	.72	.45	.70		
8	.48	.71	.14	.70		
9	.33	.71	.45	.71		
10	.19	.70	.77	.71		
11	* .10	.70	1.03	.71		
12	.19	.69	1.20	.72		
13	.33	.69	1.27	.72		
14	.48	.68	1.27	.72		
15	.62	.68	1.19	.72		
16	.76	.67	1.02	.72		
17	.88	.68	.77	.73		
18	.98	.67	.44	.73		
19	1.07	.67	* .10	.72		
20	1.15	.67	.44	.71		
21	1.22	.67	.77	.70		
22	1.27	.67	1.02	.70		
23	1.29	.67	1.18	.70		
24	1.31	.67	1.26	.70		

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-96 Date 17 Aug. 1966

Line No. FL-3-43 Operator Erickson

Output Voltage from Generator k,57 volts

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.28	.76	1.30	.78	.	.
2	1.21	.76	1.37	.78	.	.
3	1.13	.75	1.36	.78	.	.
4	1.03	.75	1.27	.78	.	.
5	.91	.74	1.08	.77	.	.
6	.78	.73	.80	.75	.	.
[illegible]	.64	.73	.42	.74	.	.
8	.48	.72	.12	.73	.	.
9	.33	.72	.48	.73	.	.
10	.17	.72	.83	.73	.	.
11	* .06	.71	1.09	.73	.	.
12	.17	.71	1.27	.73	.	.
13	.33	.71	1.34	.73	.	.
14	.49	.71	1.34	.74	.	.
15	.64	.70	1.25	.75	.	.
16	.78	.70	1.08	.75	.	.
17	.91	.70	.80	.75	.	.
18	1.02	.70	.44	.75	.	.
19	1.12	.70	* .07	.74	.	.
20	1.20	.70	.44	.74	.	.
21	1.27	.70	.80	.73	.	.
22	1.32	.70	1.08	.72	.	.
23	1.34	.70	1.25	.72	.	.
24	1.36	.70	1.33	.72	.	.

* Maximum or minimum voltage on the line

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-96 Date 18 August 1966

Line No. CL-3-133 Operator ________

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	9.5+j100* j	9.4+j96* j	9.8-j235* j	9.5-j236* j	j* j	j* j
Z Short Circuit	5.6-j94* j	5.1-j90* j	14.5+j310* j	15+j310* j	j j	j* j
Z_{50} ohm	52-j5* j	50-j8* j	51-j12* j	50-j15* j	j* j	j* j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 55.7 $\angle 4.1°$	j 52.3 $\angle 2.1°$	j 51.2 $\angle -.8°$	j 51.5 $\angle -1.2°$	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-96 Date 18 August 1966

Line No. FL-3-43 Operator Hyatt

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	9+j97 * j	8.8+j92 * j	10.4-j253 * j	10.3-j260 * j	j * j	j * j
Z Short Circuit	6-j94 * j	5.5-j89 * j	13.1-j276 * j	14-j282 * j	j * j	j * j
Z_{50} ohm	51-j2 * j	49-j6 * j	50-j7 * j	51-j16* j	j * j	j * j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 53.7 $\angle -1.5°$	j 51 $\angle -1.7°$	j 50.3 $\angle -76.6$	j 51.8 $\angle -76.5$	j	j
$\gamma_d = 1/2 \cdot \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

ANTENNA MEASUREMENTS

Date Recorded 25 August 1966

By Marvin L. Higgins

Vehicle: Type Nike Hydac

Number #102: D-11 #103: Cert. Rnd. (Tapped Line)

Diameter 9 inches

Length 10 feet

Irregularities Both nose tip and the rocket are removed, leaving the 10 foot long right circular cylinder.

System: Balanced X Unbalanced

Antenna: Type Telescoping Ralph

Length

Detailed Description (Material, wire diameter, etc.):

Mounting: Type

Standard [ ] Not Standard [ ]

Position: Distance from Nose to Antenna Center 48 inches

If not centered, explain

Antenna Cable Length 6 5/8 inches

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 2.0 Mhz, 5.0 Mhz

Approved By

112-7/66

Impedance Data:

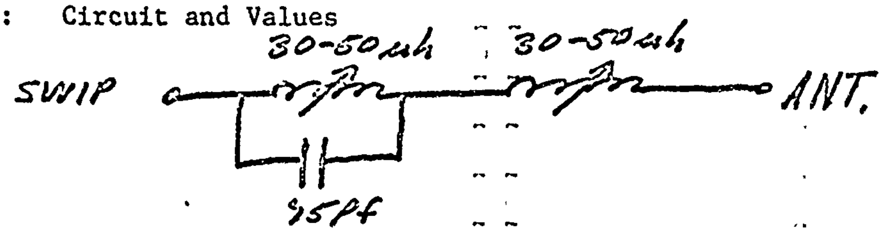
Oridinal data recorded in Notebook 263 Marvin L. Higgins
No. Name

Page 22 Date 24 August 1966

Frequency in MC	Corrected Impedance (Ant. shunt capacitance included)	
	#102	#103
1.0	0-j3158	0-j3102
2.0	0-j1573	0-j1545
3.0	0-j1041	0-j1022
5.0	0-j603	0-j507
7.2	0-j393	0-j385
12.0	7.9-j174	5.7-j175

Shunt Capacitance: 20.4 pf.

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency (Mhz)	Impedance	
	#102	#103
2.0	32.9+j49.8	32.3+j49.8
5.0	21.5+j49.9	21.3+j49.8

Upper Air Research
Form No. 100A
Date 22 Aug 1966

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IMPEDANCE PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	Solar Eclipse D-13	
Electronics Box Code No.	11116-NH-95	
Experiment Type	Balanced comm. line	
Experiment Frequencies	2.0 mc	5.0 mc
Corresponding Mode Voltages	1.04	4.4
Line Z_0 *	53	50
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *		
R.F. Cable Information		

A. Type RG-138

B. Lengths Internal to Experiment Box 14"

C. Lengths External to Experiment Box 28"

D. Total Lengths 42"

II. CALIBRATION INFORMATION

A. Laboratory Checkout

1. Persons Responsible Hyatt
2. Date 22 Aug. 1966
3. Form of Calibration Data visicorder
4. Present Data Location Upper Air Research Labs
5. Electronics Box Weight 3 lb. 12 oz.
6. Current Drain 240 ma Voltage 28

B. Field Checkout - Location ______

1. Persons Responsible ______
2. Date ______
3. Form of Calibration Data ______
4. Present Data Location ______

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

Upper Air Research
Form No. 100A
Date 22 Aug 1966

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load 470 k

B. Calibration Box

1. No. 1 (3 mc) For 2.0 MC
2. No. 2 (7.2 mc) For 5.0 MC

C. RF Voltage Level at Antenna Jacks

1. 2.2 v P.P. at 5.0 MC
2. 2.3 P.P. at 2.0 MC

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.
Fixed line	CEL 11075 FL-3-41
Ref. voltage	CEL 11106
Comm. line	CEL 11105 CL-3-132
RF switch M1	CEL 11110
2 mc osc. M3	CEL 11108 0-3-24
Osc switch M1	CEL 11074
5 mc osc. M3	CEL 11108 0-3-18
Osc. sw. driver	CEL 11073 D-1-1

Comments:

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-95 Date 17 August 1966

Line No. CK-3-132 Operator Erickson

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5.00146		FREQ.	
	OPEN	50 Ω	OPEN	50 Ω		50 Ω
1	1.26	.76	1.17	.75		
2	1.19	.75	1.23	.74		
3	1.11	.75	1.22	.74		
4	1.01	.75	1.14	.73		
5	.90	.74	.97	.71		
6	.77	.74	.62	.69		
7	.63	.74	.40	.67		
8	.47	.73	.12	.66		
9	.32	.73	.43	.68		
10	.17	.72	.75	.69		
11	* .06	.72	1.00	.69		
12	.17	.71	1.14	.69		
13	.32	.71	1.23	.70		
14	.48	.70	1.22	.70		
15	.63	.70	1.14	.70		
16	.76	.70	.98	.70		
17	.88	.70	.73	.69		
18	.99	.70	.40	.68		
19	1.09	.69	* .07	.68		
20	1.17	.69	.40	.68		
21	1.24	.69	.72	.68		
22	1.29	.69	.97	.68		
23	1.33	.68	1.13	.68		
24	1.33	.68	121	.67		

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. 11116-NH-95 Date 17 August 1966

Line No. FL-3-41 Operator Erickson

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 2 mc		FREQ. 5 mc		FREQ.	
		50 Ω		50 Ω		50 Ω
1	1.23	.73	.43	.76		
2	1.16	.72	.17	.76		
3	1.08	.72	.40	.75		
4	.98	.71	.76	.73		
5	.87	.70	1.05	.71		
6	.75	.69	1.25	.70		
7	.62	.69	1.36	.70		
8	.47	.68	1.38	.69		
9	.32	.67	1.28	.68		
10	.17	.68	1.08	.68		
11	* .07	.68	.77	.69		
12	.17	.67	.40	.69		
13	.32	.67	* .08	.70		
14	.47	.66	.40	.71		
15	.62	.66	.77	.71		
16	.75	.66	1.08	.71		
17	.88	.66	1.30	.71		
18	.98	.66	1.43	.71		
19	1.08	.66	1.45	.70		
20	1.16	.66	1.36	.70		
21	1.23	.66	1.17	.70		
22	1.28	.66	.89	.69		
23	1.31	.66	.54	.69		
24	1.33	.66	.18	.68		

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-95 Date 17 August 1966

Line No. CL-3-132 Operator Hyatt

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	9.4+j98* j	9.1+j94* j	10-j241* j	9.6-j241* j	j* j	j* j
Z Short Circuit	5.9-j95* j	5.5-j90* j	13.9-j285* j	14.1-j283* j	j* j	j* j
Z_{50} ohm	52+j4* j	495-j7* j	50-j16* j	49.5-j17* j	j* j	j* j
$Z_o = \sqrt{Z_{oc}Z_{sc}}$	j 54.2 ∠-1.7	j 51.8 ∠-1.7	j 50.3∠-76.4	j 50 ∠-76.5	j	j
$\gamma_d = 1/2 \cdot \ln \frac{Z_o+Z_{sc}}{Z_o-Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. 11116-NH-95 Date 17 August 1966

Line No. FL-3-41 Operator Hyatt

Calibration Check Freq.	1.8 mc		5.4 mc			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	8.6+j93 * j	8.5+j89 * j	11.4-j278 * j	11.1-j286 * j	j * j	j * j
Z Short Circuit	6.2-j98 * j	5.8-j94 * j	11.5+j243 * j	12.4+j60 * j	j * j	j * j
Z_{50} ohm	52+j2 * j	49.5-j6 * j	50-j8 * j	51-j20 * j	j * j	j * j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	j 53.8 $\angle -1.5°$	j 51.4 $\angle -1.7$	j 49.2 $\angle -1°$	j 52 $\angle -1.3°$	j	j
$\gamma_d = 1/2 \ln \frac{Z_o+Z_{sc}}{Z_o-Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in mc.

110-9/66

ANTENNA MEASUREMENTS

Date Recorded 25 August 1966

By Marvin L. Higgins

Vehicle: Type Nike Hydac

Number D-13: #105 to tapped line

Diameter 9 inches

Length 10 feet

Irregularities Both nose tip and the rocket are removed, leaving the 10 foot long right circular cylinder.

System: Balanced [X] Unbalanced [ ]

Antenna: Type Telescoping Ralph

Length

Detailed Description (Material, wire diameter, etc.):

Mounting: Type

Standard [ ] Not Standard [ ]

Position: Distance from Nose to Antenna Center 48 inches

If not centered, explain

Antenna Cable Length 6 5/8 inches

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 2.0 Mhz, 5.0 Mhz

Approved By

112-7/66

Impedance Data:

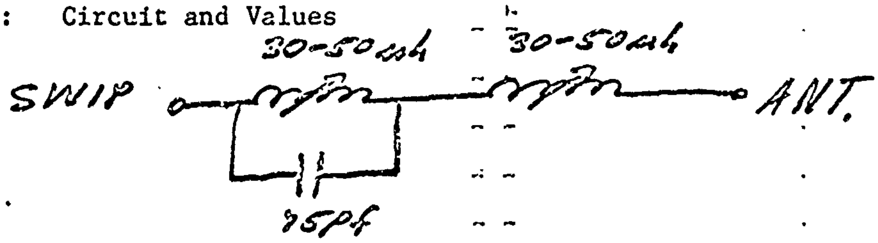
Oridinal data recorded in Notebook 263 Marvin L. Higgins
No. Name

Page 21 Date 24 August 1966

Frequency in MC	Corrected Impedance (Ant. shunt capacitance included)	
	#104	#105
1.0	0-j2898	0-j2848
2.0	0-j1455	0-j1267
3.0	0-j969	0-j944
5.0	0-j568	0-j560
3.2	0-j385	0-j377
12.0	0-j206	1.4-j204

Shunt Capacitance: 24.4 pf.

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency (Mhz)	Impedance	
	#104	#105
2.0	27.3+j50.2	27.6+j50.2
5.0	21.2+j49.3	20 7+j49.3

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13. ABSTRACT

This report details instrumentation designed to measure the parameters in the D-region of the ionosphere during a total solar eclipse. Four Nike-Hydac rockets were fired from Cassino, Brazil, in connection with the eclipse of 12 November 1966; a test flight round was flown on 5 November, and the remaining three rockets were fired during various phases of the eclipse on 12 November.

The rocket payloads were identical and were designed to measure the following parameters:

1. Positive ion composition
2. Positive ion density
3. Positive ion energy distribution
4. X-ray flux
5. Lyman-α radiation
6. Electron density
7. Electron temperature

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